

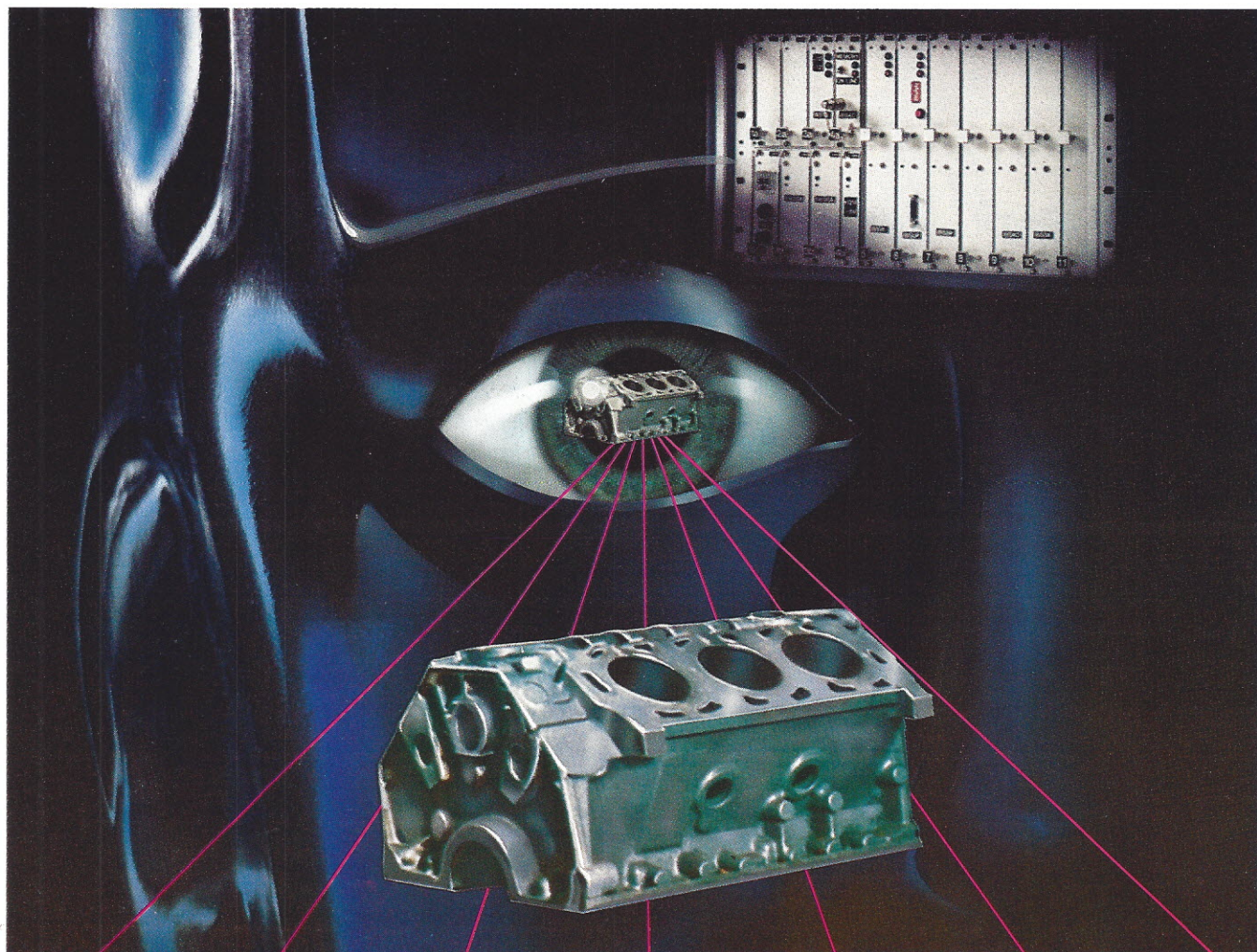
ROBOTICS

E N G I N E E R I N G

THE JOURNAL OF INTELLIGENT MACHINES



**Robotics in
Hazardous Environments
Robotic Die Casting
Robotics Databases**



**Multiprocessor
based robotics
controllers
with integrated
PLC; robot
guidance and
vision systems
...that's high
technology
from AEG!**

AEG believes that industrial automation should be simple, reliable, flexible and easy to operate. Our technology has made that belief a reality with the R-500 programmable robot controller.

The R-500 is a modular, distributive, multiprocessor based system which provides high speed computing power while remaining completely user friendly through its English text programming. The design includes linear and rotational motion control, vision systems interfaces and communications capabilities such as LAN, MAP and others.

This system provides a built-in integrated programmable logic controller (PLC) which eliminates the need for separate PCs and effectively provides total control of the workcell.

Our industrial vision system operates much like the human eye in that the camera is the functional equivalent of that organ which "sees" products on the line in gray-scale. Pre-processing is handled by the electronic interface while the vision controller, which is high speed multiprocessor based, performs the decision making processes. AEG firmware supports applications such as part recognition, inspection tasks and robot guidance. AEG is a worldwide source for technological innovation in areas which include not only robotics but, information systems, satellites, solar power, electronic packaging, power semiconductors, technical tubes and office systems.

For more information on our vision system and programmable robot controllers contact our Detroit office:

AEG Corporation
17177 North Laurel Park
Drive
Livonia, MI 48152
(313) 591-2233.

For more information on our other high technology products contact our corporate headquarters:

AEG Corporation
Route 22-Orr Drive
PO Box 3800
Somerville, NJ 08876-1269
or call (201) 722-9800.

AEG

Publisher
Chris Crocker

Editor
Carl T. Helmers, Jr.

Associate Editor
Stephanie vL Henkel

Consulting Editors
Rakesh Mahajan
Robert E. Parkin, Ph.D.
Roberta Toth

Editorial Coordinator
Lorraine Cleveland

Production/Design Director
David Wozmak

Production Assistant
Ruth S. Wilder

Circulation Manager
James E. Bingham

Circulation Assistants
Deborah Louzier
Winnie Werth

Dealer Accounts
Meredith Makela

Typography
Sheryl Fletcher

Receptionist
Erin Cuddemi

Advertising Manager
Donna Louzier

Advertising Coordinator
Cheryl Wilder

Advertising Sales

Brian R. Beihl
Associate Publisher
Robotics Age Inc.
174 Concord Street
Peterborough, NH 03458
603-924-7136

Member of
Business Publications Audit



ROBOTICS ENGINEERING—(ISSN 0197-1905) is published monthly by Robotics Age Inc., Strand Building, 174 Concord Street, Peterborough, NH 03458, phone (603) 924-7136. Address subscriptions, changes of address, USPC Form 3579, and fulfillment questions to *Robotics Engineering* Subscriptions, 174 Concord Street, Peterborough, NH 03458. Second class postage paid at Peterborough, NH and at additional mailing offices. **POSTMASTER:** Send address changes to ROBOTICS ENGINEERING, 174 Concord St., Peterborough, NH 03458.

Subscriptions are \$24 for one year (12 issues), \$45 for two years (24 issues), \$63 for three years (36 issues) in the USA and its possessions. In Canada and Mexico, subscriptions are \$28 for one year, \$53 for two years, \$75 for three years. For other countries, subscriptions are \$32 for one year, surface delivery. Air delivery to selected areas at additional charges, rates upon request. Single copy price is \$3 in the U.S., \$3.50 in Canada and Mexico, \$4 in Europe, and \$4.50 elsewhere. Foreign subscriptions and single copy sales should be remitted in United States funds drawn on a U.S. bank.

Address all editorial correspondence to the Editor at *Robotics Engineering*, Strand Building, 174 Concord Street, Peterborough, NH 03458. Opinions expressed by the authors of articles are not necessarily those of *Robotics Engineering*. To aid in preparation of acceptable articles, an Authors' Guide is available upon request, if accompanied by a self-addressed 8½ by 11 inch envelope with first class postage for 3 ounces. Unacceptable manuscripts will be returned if accompanied by a self-addressed envelope with sufficient first class postage. Not responsible for lost manuscripts or photos.

16mm microfilm, 35mm microfilm, 105mm microfiche and article copies are available through University Microfilms International, 300 North Zeeb Rd., Ann Arbor, MI 48106.

Each separate contribution to this issue, and the issue as a collective work, is © 1985 Robotics Age Inc. All rights reserved. Copying done for other than personal or internal reference use without the permission of Robotics Age Inc. is prohibited. Requests for permission should be addressed in writing to *Robotics Engineering* Permissions, Strand Building, 174 Concord Street, Peterborough, NH 03458.

THE JOURNAL OF INTELLIGENT MACHINES

ROBOTICS

ENGINEERING

MARCH 1986

VOL. 8 NO. 3

EDITORIAL

You're Liable—Watch Out

by Carl Helmers

FEATURES

5 Robots in the Real World of Die Cast Foundries by William A. Wiesmueller

Choosing the right machine for the operation can make the difference between financial survival or failure. This set of guidelines will advise the potential purchaser.

10 Mobile Robots Designed for Hazardous Environments by Harvey B. Meieran and Floyd E. Gelhaus

A new generation of robots is being designed and developed to replace or assist humans in hazardous surroundings. Robotic specifications in eight hostile environments are examined in this survey.

18 Robotics Databases by Thomas W. Conkling

The growth of the robotics industry has been accompanied by a host of allied supportive services. A user's reference to robotics databases is presented in specific detail.

22 Robotic and Remotely Operated Technology in Hazardous Waste Sites by Eugene B. Silverman

Investigating and examining a radiation leak is hazardous work. A human-robot collaboration can improve both data accuracy and human safety levels.

DEPARTMENTS

- 3 Calendar
- 4 Letter
- 25 In The Robotics Age
- 30 New Products
- 34 Classified Advertising
- 34 Advertiser Index



About the cover: This month's cover photo, supplied by E.A. DOYLE MFG. CORP., features a GMF Robotics MI-A robot set up for a die casting operation. The robot is shown placing a transmission housing into a trim die where the flashing will be removed. See related article on page 5.

You're Liable—Watch Out

BY CARL HELMERS

The other day, we had a fascinating conversation with a gentleman from a firm that manufactures welding robots. We covered a wide range of issues relevant to the engineering of practical robotic systems, from safety to software. It would be impossible to relate the breadth of an intense hour of conversation in just one editorial. Any one of the topics we discussed could end up being a book in itself.

Perhaps the most critical subject we covered was the problem of safety, safety practices, and the liability insurance problems that are endemic in our commercial civilization at present. Perhaps the biggest safety problem stems from the anthropomorphic model of an automatic system with a robot arm, a subject about which we wrote in last month's *Robotics Engineering*. If automated systems are conceptually confused with people, then

it seems only natural for normally gregarious people to be in physical proximity to their robotic "co-workers"—at a potentially terrible price in accidents.

From accidents, in modern practice, we get "settlements" and—in extreme cases—lawsuits. To protect themselves against such economic hazards, the manufacturers add tempting deep pockets through insurance. These deep pockets offer bait for the contingency fee tort lawyer. Plaintiffs' lawyers, being professionals hired to do a job, all too often win substantial settlements in or out of court—tapping the deep pockets. So, the price of our industrial liability insurance goes up.

Wherever there is the potential for inadvertently causing loss of life and/or limb, the problem mounts—in robotics, medicine, aviation, architecture, mining, and manufacturing. In the general

aviation industry, for example, we've recently heard it said that 30 percent of the cost of a new light airplane is the cost of liability insurance for the manufacturer. The whole liability insurance/legal services mess is but a Band-Aid that does not help the unfortunate person who attempted to mix with his or her robotic co-worker in a friendly manner. A far more humane and economically sound solution is to prevent the accident in the first place.

So, in robotics, safety becomes an issue of how to prevent people from getting in the way of fast-moving machinery. We start with the obvious approaches such as fences and black and yellow hazardous area markers on the floor. Then we add floor mats, people-sensing systems, low-speed operation in "teach mode" and the like. In clean room applications there is a natural barrier between the external world and the internal automatic work world—do we allow humans in at all to compromise cleanliness, let alone get smashed by a wayward manipulator arm? In dirty environments, the locked cage is always an option to consider. All are attempts to answer the fundamental safety question: How do we, through design, physically and logically isolate the machine from easily damaged humans?

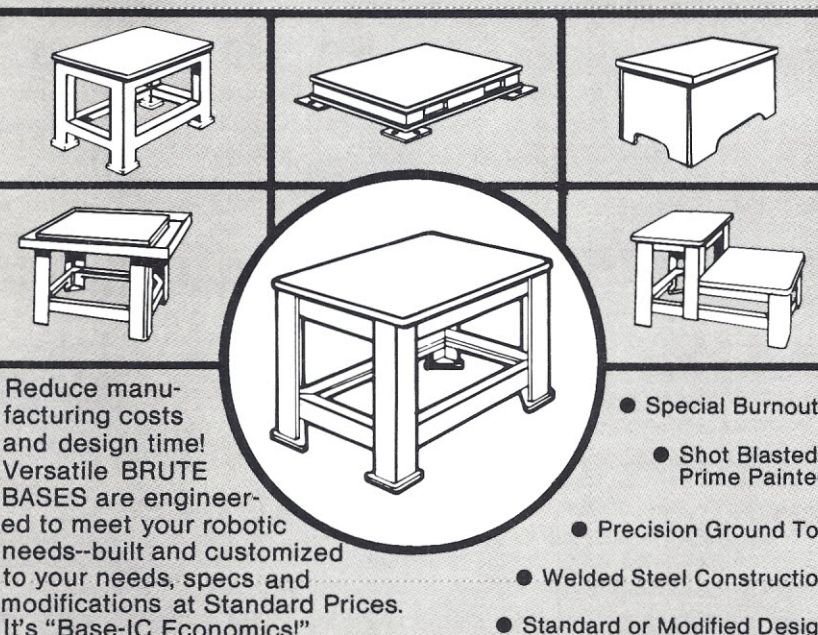
In the aforementioned conversation, we agreed that there are a lot of simple and effective safety measures that should be standard practice for all robotic system manufacturers and installers. For example, to highlight the energized state of an arm, flashing yellow caution lights have become an increasingly common warning method. At robot shows, we've seen these typically mounted atop the base of an arm, or in a fixed position on a nearby equipment cabinet or wall. Our manufacturing friend pointed out a highly effective improvement on this technique—the use of a yellow filtered flashing strobe mounted right at the end effector of a manipulator. When the manipulator is in an operating state, the strobe is activated as a warning. Our readers could supply many more suggestions.

Safety is an issue that should be automatically considered in every design and every installation of automated equipment. An audit of the safety performance of each component of a system should be as much a part of the engineering process as are audits of the performance aspects of the design. Simple, cost-effective safety measures that add an extra measure of protection often result from such a critical examination. The penalties of not thinking about this issue are the moral problems of unnecessary damage to people, and the consequential financial implications. ■

Circle 38

BRUTE MACHINE BASES

Customized To Your Needs at Standard Prices



- Special Burnouts
- Shot Blasted--Prime Painted
- Precision Ground Top
- Welded Steel Construction
- Standard or Modified Design

Reduce manufacturing costs and design time! Versatile BRUTE BASES are engineered to meet your robotic needs—built and customized to your needs, specs and modifications at Standard Prices. It's "Base-IC Economics!"

Shown above are representative BRUTE designs. CHALLENGE US to build a base to your design and specifications!

Write for our new FREE Idea File! **AMERICAN GRINDING AND MACHINE COMPANY** 2000 N. Mango Chicago, IL 60639 IN A HURRY? CALL OUR "HOT LINE"! (312) 889-4343

Calendar

MARCH

2-5. **Robotic Solutions In Aerospace Manufacturing.** Orlando Marriott Hotel, Orlando, FL. Contact: David Visscher, Robotics International of the Society of Manufacturing Engineers, One SME Dr., PO Box 930, Dearborn, MI 48121, telephone (313) 271-1500, ext. 354.

3-5. **Robotics Seminar.** IIE Education Center, Atlanta, GA. Contact: Institute of Industrial Engineers, 25 Technology Park/Atlanta-Norcross, GA 30092, telephone (404) 449-0460.

3-6. **Flexible Manufacturing Systems.** Hyatt Regency O'Hare, Rosemont, IL. Contact: John McEachran, Special Programs Division, Society of Manufacturing Engineers, One SME Dr., PO Box 930, Dearborn, MI 48121, telephone (313) 271-1500.

3-6. **Agri-Mation 2 Conference and Exposition.** Chicago Hilton Hotel & Towers, Chicago, IL. Contact: Public Relations Department, Society of Manufacturing Engineers, One SME Dr., PO Box 930, Dearborn, MI 48121, telephone (313) 271-0777.

5-7. **Expert Systems.** Doubletree Inn, Monterey, CA. Contact: Continuing Education Institute, 10889 Wilshire Blvd., Los Angeles, CA 90024, telephone (213) 824-9545. (To be repeated 19-21 March at Holiday Inn, Government Center, Boston, MA; and 2-4 April at Amfac Hotel, Los Angeles, CA.)

6-7. **IBM CAD/CAM Strategies; Using Personal Computer-based CAD/CAM Systems in Large Organizations; and How to Buy Your Second CAD/CAM System.** (Three workshops). Westgate Hotel, San Diego, CA. Contact: CAD/CAM Publishing, Inc., 841

Turquoise St., Suite D, San Diego, CA 92109, telephone (619) 488-0533.

12-14. **Artificial Intelligence for the Automotive Industry.** Westin Hotel, Detroit, MI. Contact: Dale Mason, SME Technical Activities Dept., Computer and Automated Systems Association of SME, One SME Dr., PO Box 930, Dearborn, MI 48121, telephone (313) 271-1500, ext. 375.

12-15. **Robotica/86.** Zaragoza, Spain. Contact: International Show of Robotic Technology and Applications, Palacio Ferial, Apartado de Correos, 108, Zaragoza, Spain, telephone 35 81 50.

17-19. **Interactive Analysis: Dynamic Feedback Systems.** Amfac Hotel, Los Angeles, CA. Contact: Continuing Education Institute, 10889 Wilshire Blvd., Los Angeles, CA 90024, telephone (213)

824-9545. (To be repeated 7-9 April at Ramada Inn, Oxon Hill, MD.)

17-20. **WESTEC '86.** Los Angeles Convention Center, Los Angeles, CA. Contact: Society of Manufacturing Engineers, One SME Drive, PO Box 930, Dearborn, MI 48121, telephone (313) 271-0023, ext. 328.

17-21. **Internet Systems and Protocols.** Contact: Dick White, The George Washington University, Washington, DC 20052, telephone (202) 676-6106 or (800) 424-9773.

17-21. **Introduction to Hydraulics.** Milwaukee School of Engineering, Milwaukee, WI. Contact: Laurie Andersen, Seminar Coordinator, NFPA, 3333 N. Mayfair Rd., Milwaukee, WI 53222, telephone (414) 778-3366.

18-20. **Southcon/86 High Tech-**

"Your search for a 50,000 count* encoder is over . . . and still under \$500.00"

Introducing the BEI M5 Interpolate Encoder.

The BEI M5 encoder provides the ability to subdivide a cycle into smaller divisions, improving system resolutions up to 50,000 counts per turn while maintaining a ± 1 count accuracy.

This increase in resolution is achieved in a standard 2.5" dia. industrial package without sacrifice to mechanical integrity or internal electrical signal strength.

The M5 is ideal for position readouts and position servos. Its features include the same options (over 17 million configurations) found in the standard BEI encoder line.

* 12,500 cycles per revolution allows quadrature detection of 50,000 counts per turn. (alternate resolutions available).

Renowned for their unmatched quality and reliability, BEI's products are backed by the finest technical and service support imaginable. And without compromising quality, BEI guarantees a 4-week delivery, even faster with optional expedited delivery!

So if you're searching for the right encoder for the right job and you need it now, search no longer. Call and talk to our experts.

Find out why BEI is recognized as "The Encoder Company". And be sure to ask for your copy of the Optical Encoder Design Guide. It's free.



BEI Motion Systems Company
Industrial Encoder Division

7230 Hollister Ave.
Goleta, CA 93117
(805) 968-0782
Telex: 888069 (BEIIED)

Calendar

nology Electronics Exhibition and Convention. Orange County Convention Center, Orlando, FL. Contact: J. Fossler, Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045, telephone (213) 772-2965.

18-21. **International Handling & Storage Exhibition—IHSE '86.** National Exhibition Centre, Birmingham, England. Contact: Keith Harris, Trinity Publishing Ltd., Station Approach, Long Lane, Hillingdon, Middlesex UB10 9NR, England.

19-21. **3rd International Conference on Automated Materials Handling.** Metropole Hotel, National Exhibition Centre, Birmingham, England. Contact: IFS (Conferences) Ltd., 35-39 High St., Kempston, Bedford MK42 7BT, England, telephone (0234) 853605.

24-26. **SYSTEMS™ 1, For Integration of Plant Automation Communications and Control.** Chicago Hilton & Towers, Chicago,

IL. Contact: Paul Borawski, Assistant Manager, Technical Activities, Society of Manufacturing Engineers, One SME Dr., PO Box 930, Dearborn, MI 48121, telephone (313) 271-1500.

24-27. **National Warehousing and Distribution Facilities Exposition and Conference/DEPO 86.** McCormick Place, Chicago, IL. Contact: Show Manager, DEPO 86, 999 Summer St., Stamford, CT 06905, telephone (203) 964-8287.

26-28. **Local Area Data Communications Networks.** Contact: Shirley Forlenzo, The George Washington University, Washington, DC 20052, telephone (202) 676-6106 or (800) 424-9773.

31-April 1. **Successful Deployment of Machine Vision.** Center for Continuing Engineering Education, Milwaukee, WI. Contact: Peter Tocups, University of Wisconsin-Milwaukee, 929 N. Sixth St., Milwaukee, WI 53203, telephone (414) 224-3952.

APRIL

1-3. **Manufacturing Productivity Conference and Exposition.** H. Roe Bartle Hall, Kansas City, MO. Contact: Public Relations Department, Society of Manufacturing Engineers, One SME Dr., PO Box 930, Dearborn, MI 48121, telephone (313) 271-0777.

3-4. **Artificial Intelligence—An Applications-Oriented Approach.** Contact: Stod Cortelyou, The George Washington University, Washington, DC 20052, telephone (202) 676-6106 or (800) 424-9773.

7-10. **1986 IEEE International Conference on Robotics and Automation.** San Francisco Hilton & Tower, San Francisco, CA. Contact: Robotics & Automation, c/o Harry Hayman, 738 Whitaker Terrace, Silver Spring, MD 20901, telephone (301) 434-1990.

8-10. **Instrumentation '86—Pacific Northwest Conference and Exhibit.** Red Lion Inn, Lloyd Center, Portland, OR. Contact: Duane Schroeder, Publicity Chairman, Control Elements, Inc., 1730 S.W. Skyline Blvd., Portland, OR 97221, telephone (503) 297-1533.

8-10. **1986 Test & Measurement World Expo.** San Jose Convention Center, San Jose, CA. Contact: Meg Bowen, Conference Director, Test & Measurement World Expo, 199 Wells Ave., Newton, MA 02159, telephone (617) 964-8900.

8-10. **15th Annual International Programmable Controllers Conference and Exposition.** Cobo Hall, Detroit, MI. Contact: Carmelita Smirnes, Media Relations Coordinator, Engineering Society of Detroit, 100 Farnsworth Ave., Detroit, MI 48202, telephone (313) 832-5400.

9-12. **CommunicAsia 86.** World Trade Centre, Singapore. Contact: Gerald G. Kallman, Five Maple Court, Ridgewood, NJ 07450-4431, telephone (201) 652-7070.

21-24. **ROBOTS '86.** McCormick Place, Chicago, IL. Contact: Robotic Industries Association, PO Box 1366, Dearborn, MI 48121, telephone (313) 271-7800.

22-24. **Quality Expo TIME.** O'Hare Expo Center, Rosemont, IL. Contact: Quality Expo TIME, 2400 E. Devon Ave., Suite 205, Des Plaines, IL 60018, telephone (800) 323-5155 (in IL, (312) 299-3131).

27-30. **Expert Systems.** Hyatt Regency, Cambridge, MA. Contact: Continuing Education Institute, 10889 Wilshire Blvd., Los Angeles, CA 90024, telephone (213) 824-9545. (To be repeated 5-7 May in Monterey, CA.)

29-May 1. **Motor City Fluid Power Show V/National Conference on Fluid Power.** Cobo Hall, Detroit, MI. Contact: G.B. Randall, 4922 Wildwood, Harrison, MI 48625, telephone (517) 539-2745.

MAY

6-8. **Control Expo 86.** O'Hare Exposition Center, Rosemont, IL. Contact: Tower Conference Management Co., 331 W. Wesley St., Wheaton, IL 60187, telephone (312) 668-8100.

6-8. **Logistex 86.** Cervantes Convention Center, St. Louis, MO. Contact: Logistex 86, 940 Western Ave., Pittsburgh, PA 15233, telephone (412) 323-1808.

13-15. **Electro/86 High Technology Electronics Exhibition and Convention.** Bayside Exposition Center, World Trade Center, Boston MA. Contact: J. Fossler, Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045, telephone (213) 772-2965.

14-16. **Fiber Optics Technology for Communications.** Contact: Ron Donais, The George Washington University, Washington, DC 20052, telephone (202) 676-8523 or (800) 424-9773.

Letters

I have just bought my first issue of your journal and I am very pleased with what I have read. Your journal is very informative and complete, and one can truly learn from this publication.

I encountered one slight typographical error in this issue (Vol. 8 No. 1). On page 17 of the article "Geometry of the Robotic Workplace and the Homogeneous Representation" you have:

$$\begin{bmatrix} a \\ b \\ c \end{bmatrix} = \begin{bmatrix} u_x^1 - u_x^2 \\ u_y^1 - u_y^2 \\ u_z^1 - u_z^2 \end{bmatrix} \times \begin{bmatrix} u_x^1 - u_x^3 \\ u_y^1 - u_y^3 \\ u_z^1 - u_z^3 \end{bmatrix} = \begin{bmatrix} (u_y^1 - u_y^2)(u_z^1 - u_z^3) - (u_z^1 - u_z^2)(u_y^1 - u_y^3) \\ (u_z^1 - u_z^2)(u_x^1 - u_x^3) - (u_x^1 - u_x^2)(u_z^1 - u_z^3) \\ (u_x^1 - u_x^2)(u_y^1 - u_y^3) - (u_y^1 - u_y^2)(u_x^1 - u_x^3) \end{bmatrix}$$

As you can see, $u_y^1 - u_y^2$ should be $u_y^1 - u_y^3$, so that you can derive the equation on the right side of the second equal sign.

Thank you for your time and great publication.

Eric Hayes
System Operator
765 Amsterdam Avenue
New York, NY 10025

Robots in the Real World of Die Cast Foundries

William A. Wiesmueller, Sr.

E.A. Doyle Mfg. Corp.
County Trunk EE
Sheboygan, WI 53081-9416

For the past ten years robots have been successfully used in progressive die cast foundries to improve quality and profitability. Today, and even more so in the future, more and more robots will be required not only to maintain profits but as a simple matter of economic survival. Competition in this industry will continue to grow from developing countries as well as from industrialized nations that take advantage of available technology and government help rather than of trade restrictions. We have already seen more than a 40 percent reduction in the number of shops over the past 20 years. The U.S. and Canadian foundries facing this intense competition must invest in professionally planned automation programs for their continued existence. There is no doubt that robots will be at the center of most of these mechanized systems.

Selecting the correct robots and their degree of automation is a critical and difficult decision die casters must make now. The fact is that it's an especially difficult direction to determine since there are so few professionals available for assistance in this area of expertise. The information in this article is being shared in the hope of helping those decision makers who will surely strengthen the die cast industry for our mutual benefit.

First-generation robots in die cast foundries were hydraulically operated spherical-coordinate units with fixed-stop point-to-point control. They were used to remove the castings from the die cast machine and thereby remove the operator from the usually severe and unpleasant environment. The benefit of labor savings can be seen in the reduction of direct and indirect costs by an average of \$120,000 per year (based on three-shift operation and a total cost per operator of \$40,000).

Another benefit realized from these first-generation robots was the increased up time of the capital-intensive die cast machine. In the average shop, a manually operated machine will run 6-1/2 hours per shift—losing 1-1/2 hours to down time necessary for breaks, startup and shutdown, lunch, and other time-consuming events. That same machine when operated by a robot will produce castings 8 hours per shift. This increase in production can mean profit increases equal to those generated by labor savings.

The highest quality castings are produced on machines that have a consistent cycle that duplicates successful parameters determined through experience and experimentation. Here again, those first robots provided for consistent cycling, resulting in improved quality. The first-generation

robots did the job they were intended to do—so well, in fact, die casters who use that technology, together with sound management principles, continue to successfully compete in the pure casting market. Now comes the competition again with value added to the casting: trimmed parts with all or a majority of machining operations completed using labor at costs of 40 cents per hour and less, and benefiting from government help.

This brings us to the point where the industry is now. Die casters are taking the next step, which includes automatic trimming, and at a slower pace adding secondary machining operations to the workcell. One of today's successful mechanized cells, the DC/2000, includes the die cast machine, GMF M1-A robot, part-present check station, quench station (not used when hot trimming), special trim press for use with robots, and material handling conveyor. With the exception of the trimmed material, which is removed by a conventional "Z" style conveyor, the robot moves and maintains casting orientation through the entire operation and interfaces individual equipment.

Future cells will include more special or standard machining centers with completed parts being removed and placed on pallets ready for packaging or shipment.

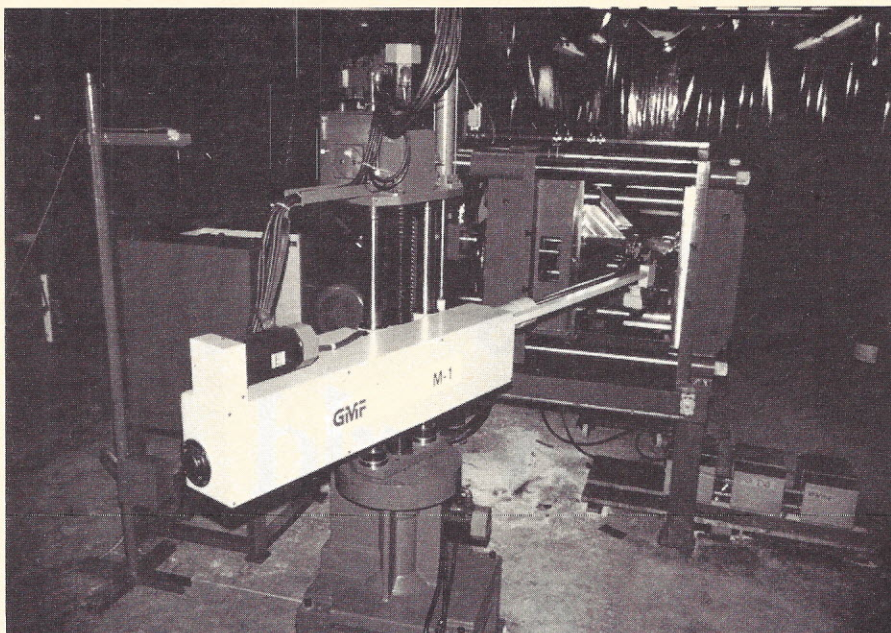
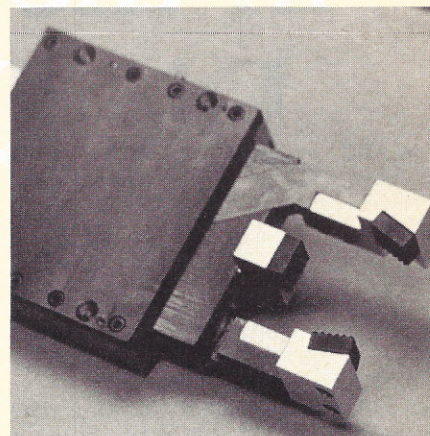
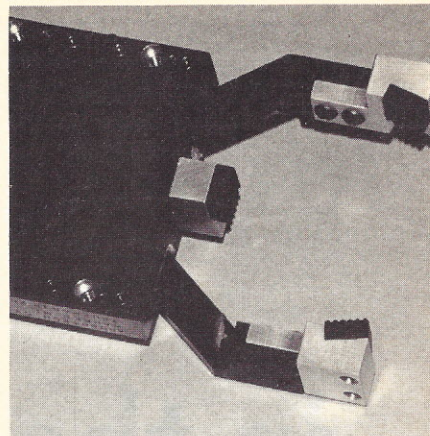
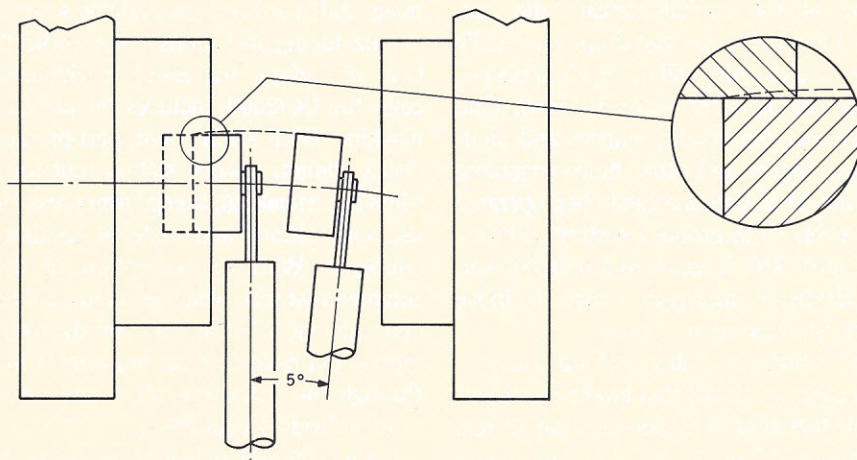
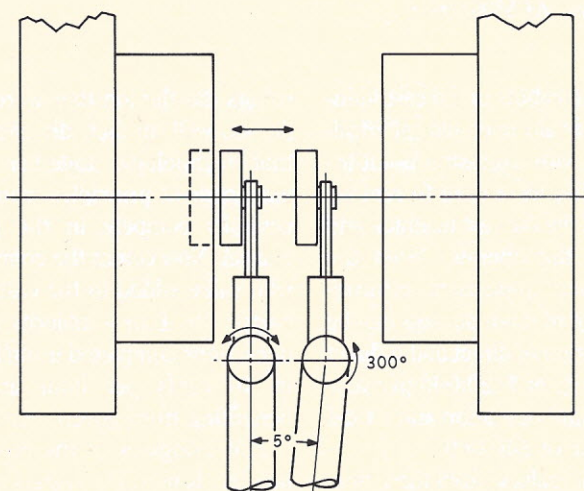


Photo 1. The GMF M1-A can unload the casting from the die cast machine, move it to quench, load it into the trim press, remove it, and put it into the machining center. After the product has been machined, the robot palletizes it for transportation away from the workstation.



Photos 2 and 3. The robot's end effector, the True-Grip from Arobotech Systems Inc., is shown in open (top) and closed configuration.



Figures 1 and 2. The GMF M Series robot (Figure 1) employs the E2 rotating wrist to insert or extract the workpiece at an angle perpendicular to the die. A robot without the wrist feature (Figure 2) can distort the workpiece, leaving it in improper orientation for insertion into the trim die.

The future cell will not only be interfaced through the robot but will also control individual machines making up the cell. This means the elimination of individual machine controls, which will free up space and reduce overall system cost.

A cell that yields completed machined parts stacked neatly on pallets and operated by one controller probably seems too futuristic. It's not. GMF Robotics now has what it calls "Karel" control, which gives us the ability to operate the robot and all cell equipment except the die cast machine from one control cabinet. A DC/2000 system now in operation at one of the major small engine manufacturers casts, trims, and machines castings, resulting in a labor reduction of 10 people while increasing individual machine up time 20 percent.

The benefits from robots that combine other equipment to form a mechanized system are apparent in improved quality and profits. Perhaps the best news is that a DC/2000 system is easily justified. A system that includes a robot, parts present

check station, quench station, special trim press, and parts handling equipment costs at present between \$130,000 and \$160,000. Those figures also include training and the mechanical and electrical engineering necessary (at least for a company's first system) for fast, effective installation and startup. E.A Doyle manufactures, sells, and installs the DC/2000 system.

CHOOSING THE CORRECT ROBOT

First-generation die cast robots removed castings from the die cast machines and placed them at random into containers. Often the runner and gating system became bent during this operation. At that time, this didn't create problems. Now robots are required to remove the casting without distortion so that orientation can be maintained through the sensing and quench station until finally the casting is placed into a trim die. These additional requirements mean that additional robot capabilities are needed.

Most present day die cast robots and those of the future will be AC motor driven cylindrical-coordinate design with four to five programmable axes that can move simultaneously. The fixed-stop, air-operated axes of the gripper are not included here.

To help select the correct robot, let's first look at the five most common robot-related problems:

1. Failure to remove the castings straight off the die, which creates binding between the die ejector pins and the parts. This causes distortion, which means the parts are no longer oriented properly for entry into the trim die. This can also cause damaged parts (Figures 1 and 2).
2. Failure caused by the robot's inability to maintain XY casting orientation between the die cast die and the trim press die when the horizontal plane between the two dies is different.
3. Excessive programming time.
4. Mechanical and electrical control failures.
5. Improper and time-consuming installation.

The solutions to these problems are as follows:

1. Today's die cast robots must incorporate a programmable wrist that operates simultaneously with the reach and rotational axes. The result

is "linear travel." A robot with a linear path control package can be quickly programmed to remove castings straight off the casting die (not in an arc) and then place them straight into the trim die. This feature will eliminate problem number 1.

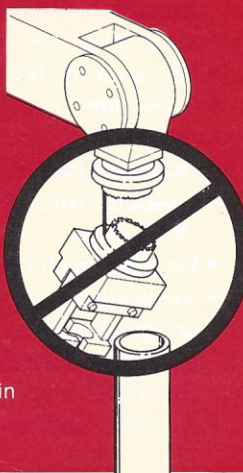
2. The second problem is solved by a cylindrical-coordinate robot or a robot with a programmable wrist that can maintain XY or horizontal orientation at various heights and rota-

tional positions.

3. Excessive programming or setup time can take as long as half a day with some units, destroying the flexibility needed to pressure cast many different parts, especially when short runs are the rule. It should be possible to program a robot from one part to the next in 15 minutes or less and then store the program in memory for future recall, which then takes about one minute. The robot mem-

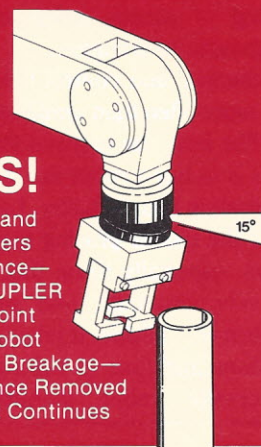
NOT THIS!

Robot Hand Encounters Resistance—Breakaway Joint Fails—Downtime Ensues—Again and Again



THIS!

Robot Hand Encounters Resistance—UNI-COUPLER Safety Joint Stops Robot Without Breakage—Resistance Removed—Robot Continues



SLASH ROBOT DOWNTIME TODAY

New! Robotic UNI-COUPLER™ Safety Joint

The UNI-COUPLER safety joint is a permanent coupling. It is designed to eliminate breakaway joints between robotic hand and arm—to stop the robot when the hand encounters overload—to accept 15° continued motion—to automatically reset when the obstruction is removed.

It gets the robot moving again . . . without reprogramming or insertion of new breakaway joints. The "trip-load" feature is infinitely variable from whisper soft to maximum setting of the UNI-COUPLER safety joint employed. Many other features!

Call or write to solve your robotic-downtime problems. Minutes to install on old robots or new.

ROBOTIC ACCESSORIES

4191 US Route 40 Tipp City, OH 45371
Telephone: (513) 667-5705 Telex: 288022

ory must therefore have enough storage for the number of parts intended to be run. The memory should be a nonvolatile magnetic type unaffected by electrical noise interference or power loss.

Two essential programming tools are the hand-held teach pendant and the CRT display in the control cabinet. The teach pendant is required for close viewing while walking the robot through the teaching process. The CRT displays large blocks of information for rapidly and accurately checking program information, the positions of all axes, and listing of access codes and self-diagnostic information.

4. Mechanical and control failures occur more often than would seem likely. The best way to avoid these failures is to buy a robot that has proven itself in your industry. Let others take the risk of proving new equipment, especially those that do not provide advantages over successful units now available. It takes multiple millions and time to belong to the successful robot manufacturers

club—ask any of those now in it.

5. Rapid and successful robot and system installation is accomplished under the direction of the systems engineers with expertise in their product. You can expect your system to run 6 to 8 months sooner with this service than you could without it. This engineering direction is most important for the first system, when the purchaser is unfamiliar with the new equipment.

Other robot features necessary for success in the die cast industry are as follows:

- Heavy-duty machine tool type construction built to operate in the most severe plant environments
- Sealed-for-life bearings
- Safety limit switches for overtravel protection
- Dust-proof maintenance access covers
- Sealed electrical connections through all housings
- Brushless motors
- Automatically calculated acceleration and deceleration slopes to avoid shock and ensure smooth operation even at continuous high speeds
- A slower teach speed

- Self-diagnostics
- Immediate parts availability
- Training before and after robot delivery
- Fan driven air-to-air heat exchanger, allowing control cabinet cooling without internal air contamination
- Accurate repeatability
- Three-point gripper self-aligning around a given center line
- Carbide gripper pads
- Immediately available and qualified service engineering
- A net load capacity capable of handling your heaviest casting

Finally, the die cast robot project deserves the time and effort it takes to make a correct decision, and remember: high technology does not mandate complexity.

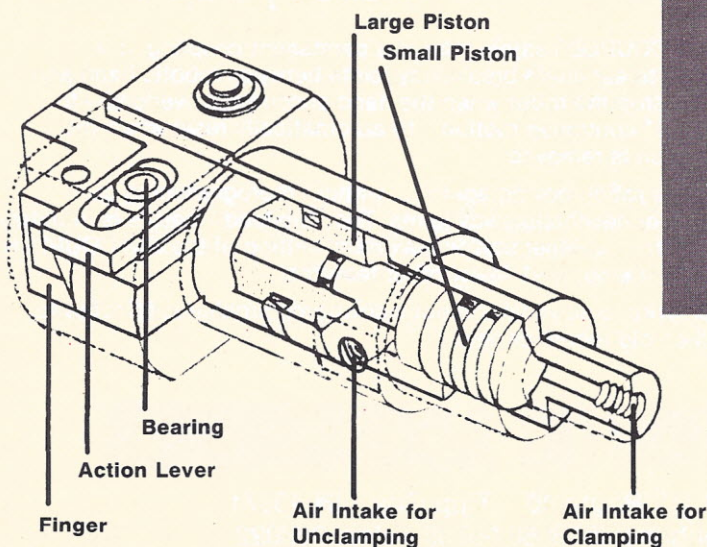
Reader Feedback

To rate this article, circle the appropriate number on the Reader Service card.

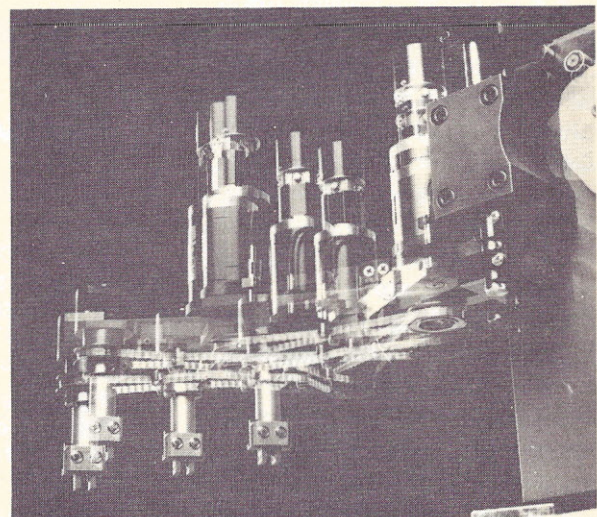
1	11	21
Excellent	Good	Fair

High Precision Parallel Motion Robotic Grippers

- Parallel clamping/unclamping eliminates deflection in grasping dimension.
- Simplicity in design allows small size, smooth operation, and quick response.
- High precision clamping mechanism ensures high precision chucking.



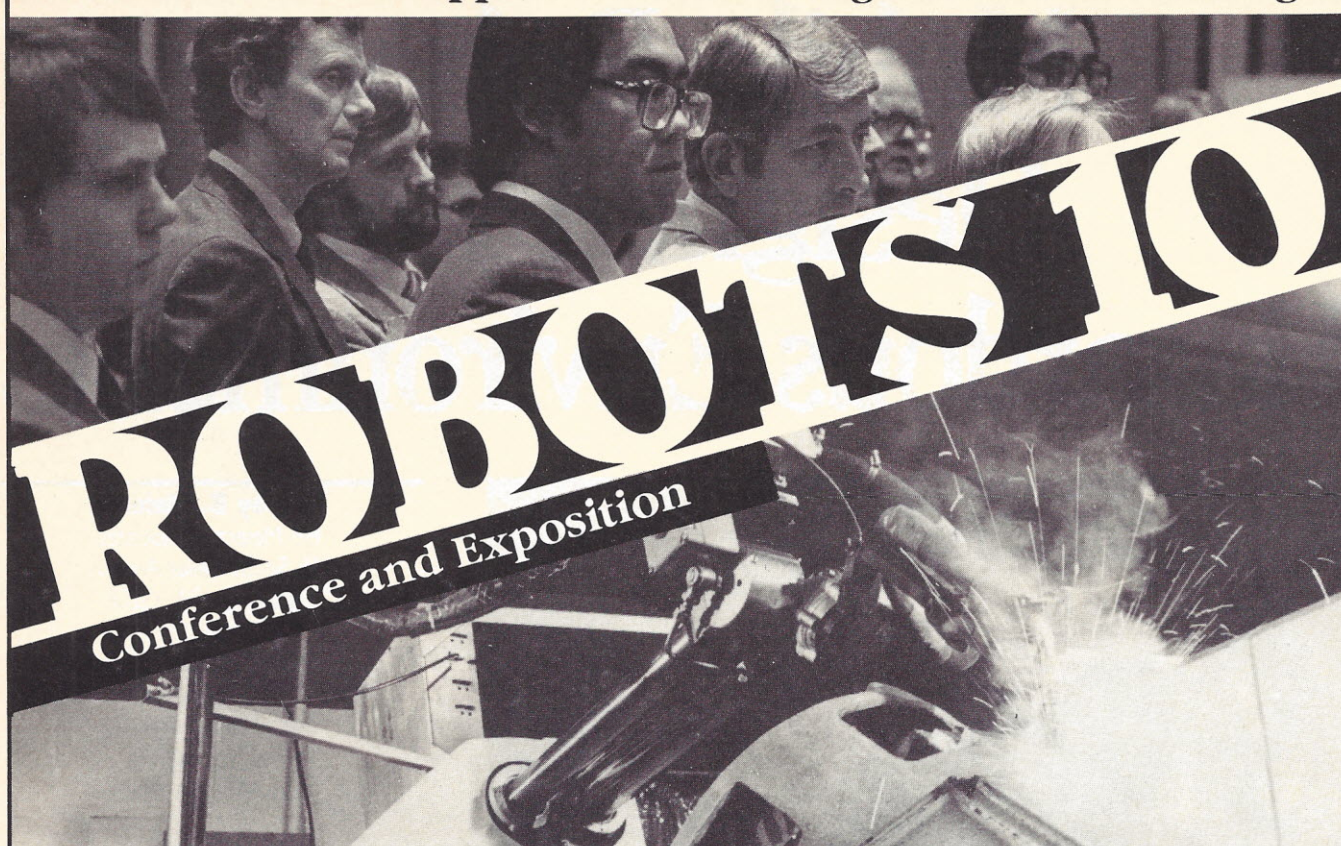
DISTRIBUTOR/OEM INQUIRIES INVITED



ASSEMBLY ROBOT INQUIRIES WELCOME

CORET & COMPANY, LTD.
Shimbashi Ekimae Bldg. No. 1
20-15, 2-chome Shimbashi
Minato-Ku, Tokyo 105, Japan
Phone 03-573-1721
Telex 2523676 TESH J
Facsimile 03-461-5698

Discover new robot applications for integrated manufacturing at



April 20-24, 1986

McCormick Place □ Chicago, Illinois

Learn how robots can make your company more productive and profitable—attend the ROBOTS 10 Conference and Exposition!

Exhibits and sessions will focus on integrated robot applications for assembly, welding, material handling, finishing, machine loading and other manufacturing processes. See over 250 robots in action during this tenth anniversary presentation of the world's most prestigious annual robotics event.

See and hear new productivity ideas from U.S. and international experts at the conference. Learn the latest advances in robotic technologies, including topics such as:

- Artificial Intelligence
- Manufacturing Automation Protocol (MAP)
- Electronics
- AGV Applications
- Aerospace
- International Applications
- Remote Systems
- Military Systems
- Automotive
- General Applications
- Research & Design
- Robot Basics
- Education & Training
- Justification

Call today for complete ROBOTS 10 details...313/271-0777.

Exposition sponsored by
Robotic Industries Association



Conference sponsored by
Robotics International of the
Society of Manufacturing Engineers



ROBOTS 10

Please send me information on: ☐ Conference Attendance
☐ Show Attendance ☐ Exhibiting

NAME _____

TITLE _____

COMPANY _____

ADDRESS _____

CITY _____

STATE _____ ZIP _____

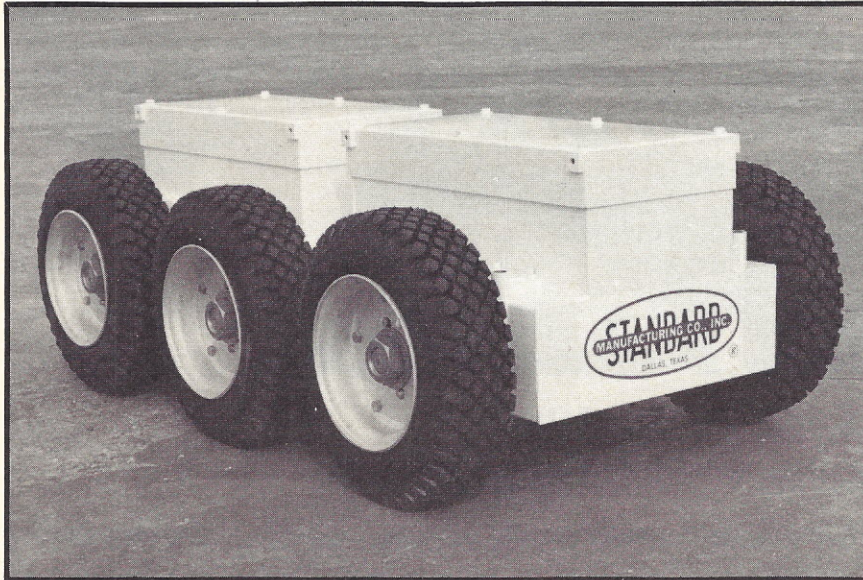
COUNTRY _____ TELEPHONE _____

Return coupon to: Public Relations Department, Society of
Manufacturing Engineers, One SME Drive, Dearborn, Michigan
48121



1

Mobile Robots Designed For Hazardous Environments



Harvey B. Meieran

HB Meieran Associates
458 South Dallas Avenue
Pittsburgh, PA 15208
and

Floyd E. Gelhaus

Electric Power Research Institute
3412 Hillview Avenue
PO Box 10412
Palo Alto, CA 94303

Tasks and missions conducted in hazardous environments are becoming more common. Human beings are usually called upon to enter these life-threatening situations. Mechanisms are therefore being developed to assist in dangerous missions and reduce personal risk. Such mechanisms can expedite the mission, make the work more reliable, and, in some cases, allow the individual to conduct the mission from a safe environment. The concept of removing the individual from a harsh environment has been actively pursued since the early days of the nuclear industry, beginning with the development of the slave arm. This device allowed the individual to manipulate highly radioactive material in shielded hot cells from a safe, nonradioactive environment in front of the hot cell complex.

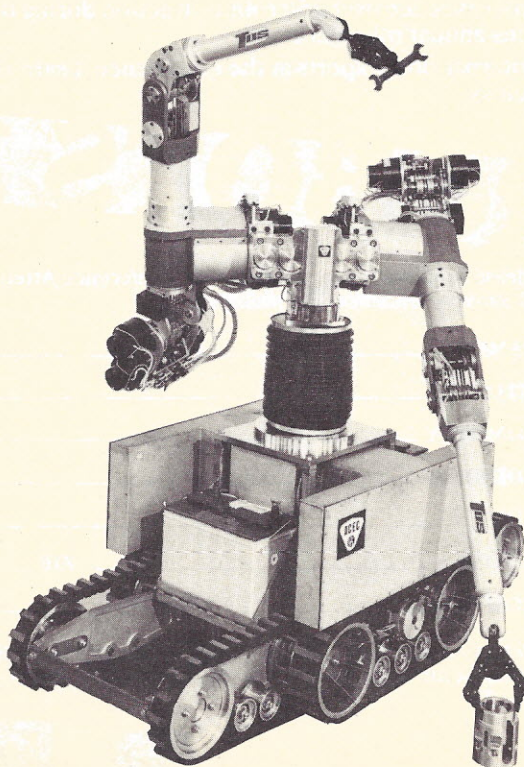


Photo 1. The MARS-V (Multipurpose Area Remote Surveillance Vehicle), Standard Manufacturing Co., Inc., Dallas, TX, is designed as a base for other robotic systems.

Photo 2. The Telemac, developed by ACEC, Belgium, and distributed by Teleoperator Systems, Inc., Bohemia, NY, has applications in the nuclear industry.

Photo 3. The Prowler, Robot Defense Systems, Inc., Thornton, CO., is an autonomous perimeter patrol robot.

Most of today's harsh environments are relatively unstructured and are frequently located where a fixed slave arm cannot be employed. It is therefore necessary to use a mobile system that can transport the mission equipment to the hazardous work station and, if possible, enable the individual to direct the operation from a safe environment. Work assignments can be controlled directly by the individual, or indirectly by intelligent systems located on board the mobile system or at the control center for the machine. Direct control via "telepresence" has been described by Jack Wilson of the Canadian firm of Robotic Systems International, Ltd., as: "the concise expression for the general concept of a human operator at one point in space experiencing the illusion of being at another location and having the ability to carry out actions at the location in a natural manner. The feedback loops necessary for simple tasks are artificially extended through space to accomplish the same ends remotely."

Several mobile teleoperated or robotic (T/R) vehicles have been designed, developed, assembled, and operated in a spectrum of hazardous environments that are representative of separate "industries." Since the environments and the "industries" have in the past generally been considered mutually independent, there has been very little coordination among the designers of these devices. Similarities in the tasks for which the robots were intended, however, have brought about similarities in vehicle design and methods of operation. A survey of T/Rs illustrated these similarities. The information here presented is drawn from the literature, manufacturers' specification documents, and a robotic systems review sponsored by the Electric Power Research Institute (Research Project RP2232-5). This survey

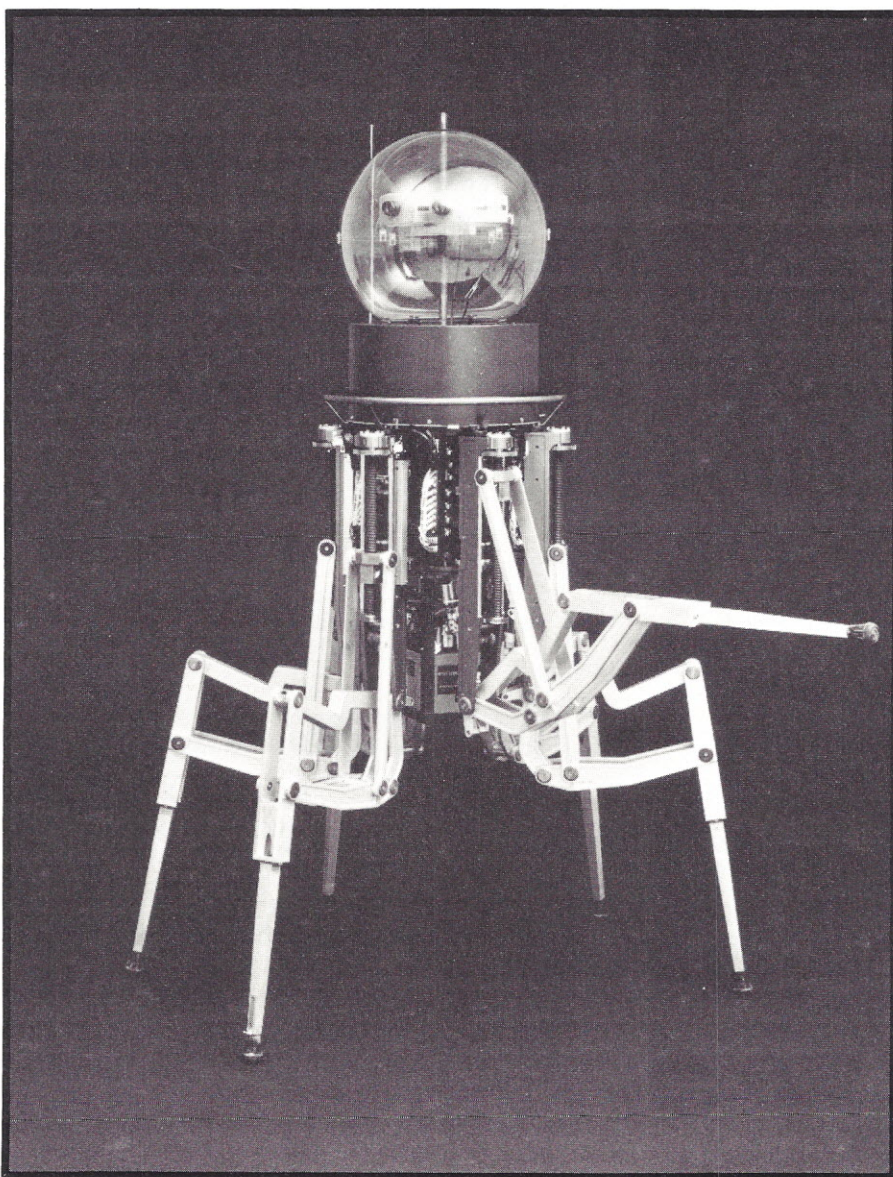
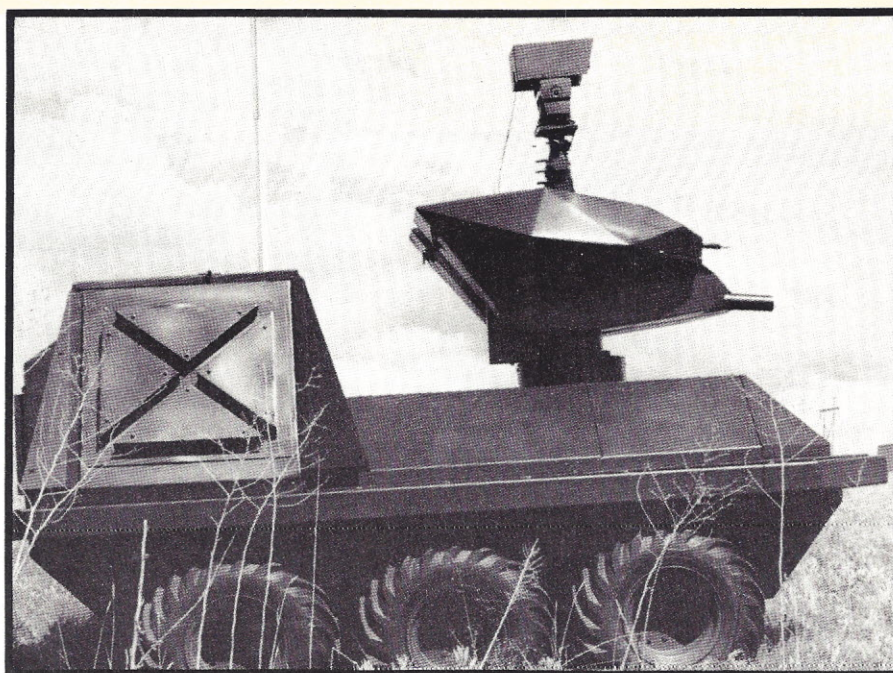


Photo 4. The ODEX, Odetics, Inc., Anaheim, CA, is a six-legged functionoid with a variety of applications.

Photo 5. The Surbot, Remote Technology Corp., Oak Ridge, TN, was designed for the nuclear power industry.

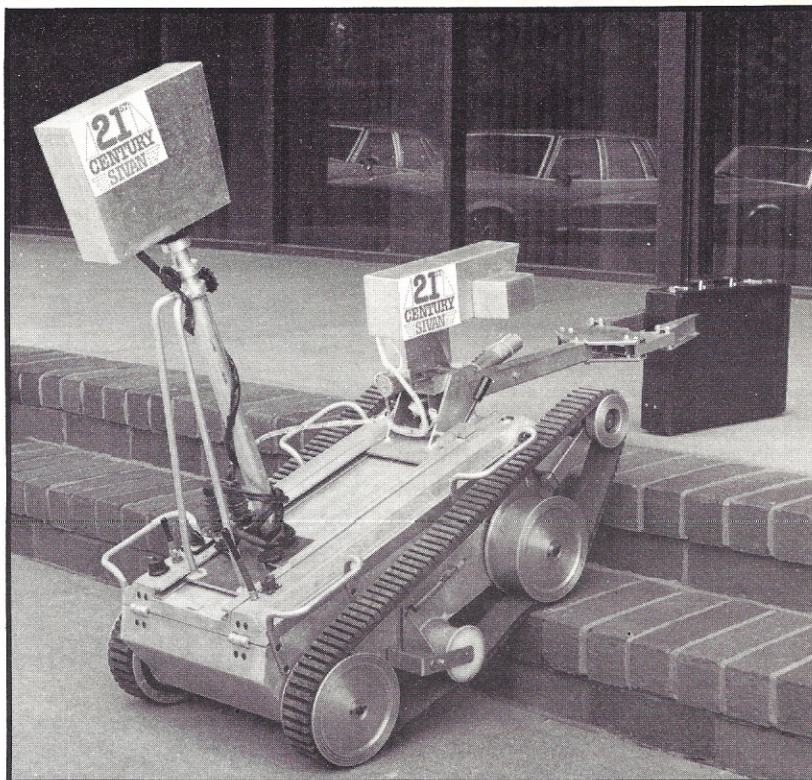
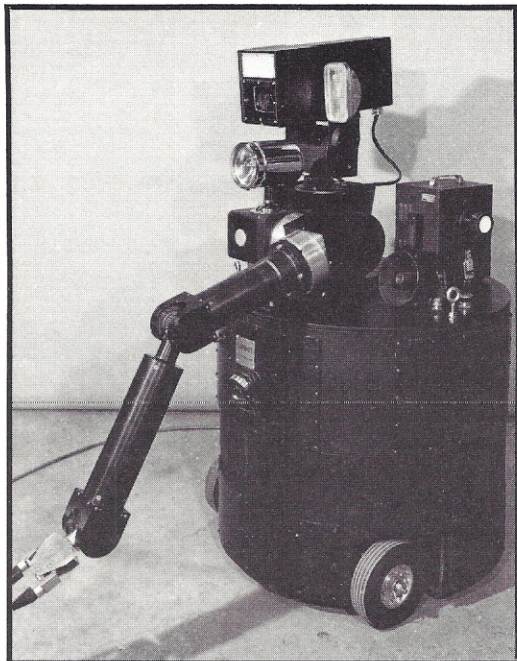


Table 1
Hazardous Environments
and Specific Task Assignments

Nuclear Industry

Fuel Fabrication	Facility Decommissioning
Facility Operation	Facility Decontamination
Facility Maintenance	Radioactive Material Handling
Radioactive Incident Response	Waste Material Storage
Radioactive Material Transportation	Site Surveillance

Civilian Security and Safety

Explosive Ordnance Disposal
Terrorist Activity Neutralization

Military

Explosive Ordnance Disposal	Security
Area Surveillance	Patrolling
Environmental Monitoring	Munitions Handling

Chemical/Toxic Hazards

Chemical Spills	Toxic Material Handling
Toxic Material Removal	Transportation Accidents
Chemical Waste Site Cleanup	Site Surveys

Mining

Roof and Wall Support	Dust Control
Emergency Assistance	

Security

Warehouse Surveillance	Prison Surveillance
Site Perimeter Patrolling	

Fire Fighting

Smoke Detection	Flame Suppression
Heat Source Locator	

Construction/Excavation

Cave-ins	Flooding
Gas Line Explosions	Electrical Discharges

Photo 6. The TSR-70, 21st Century Robotics, Inc., Norcross, GA, is intended for civilian and military ordnance disposal.

makes no claim to include 100 percent of the robots designed for hazardous work. Manufacturers of 69 T/Rs in nine countries were included in the study. The following is a listing of the number of manufacturers, followed by the number of units produced: Belgium, 1/1; Canada, 2/3; France, 1/3; Germany, 2/4; Ireland, 1/1; Israel, 1/3; Japan, 6/11; the United Kingdom, 3/5; and the United States, 23/37.

The hazardous environments and specific task assignments presented here are those associated with the nuclear industry; civilian security and safety; the military; chemical/toxic hazards; mining; security; fire fighting; and construction/excavation. Some of the specific task assignments associated with each field are shown in Table 1. The focus of this review is solely on vehicles that operate on land or that are amphibious; robots under development by the U.S. Department of Defense for personnel and weapons systems transport are omitted, as are the vehicles employed in underwater hazardous environment missions.

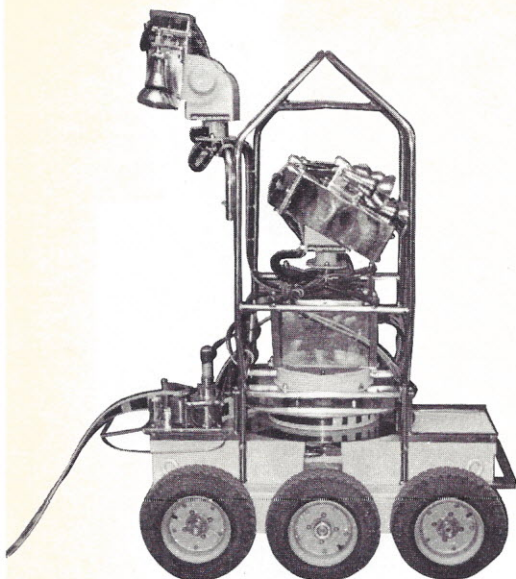


Photo 7. A superstructure designed at Carnegie-Mellon University and mounted on Standard Manufacturing's MARS-V (see Photo 1) became the T.M.I. RRV (Remote Reconnaissance Vehicle), developed to enter the contaminated areas of the Three Mile Island nuclear power plant.

MISSIONS AND DESIGN

The basic components for each of the mobile T/R vehicle systems are: the means of locomotion/propulsion; the power supply; command/data communications techniques; on-board sensory and equipment packages; arms and other robotic boom or claw type manipulators; electronics; computer/microprocessor; and the command console/desk/station.

Table 2
Summary of Locomotion Techniques

5-Legged	1	2-Tracked	28
6-Legged	4	4-Tracked	4
8-Legged	1	6-Tracked	2
2-Wheeled	1	5-Wheeled	1
3-Wheeled	7	6-Wheeled	10
4-Wheeled	10	8-Wheeled	1

In reviewing the configurations for the T/R vehicles, it was noted that three basic modes of locomotion were considered by the individual developers: legged, tracked, and wheeled. The statistics for locomotion techniques are presented in Table 2. Locomotion technique and the number of legs, tracks, or wheels for each vehicle were determined by the designer's judgement of the scope of the missions the vehicle was to carry out and by the mission environ-

Table 3
Specific Missions Conducted

Nuclear

Air Sample	Tool Transport
Smear Sample	Bolt/Unbolting
Sludge Sample	Sludge Removal
Radiation Surveillance	Visual Inspections
Temperature Surveillance	Duct Cleaning
Humidity Surveillance	Duct Surveillance
Wall Cleaning	Concrete Core Sample
Concrete Surface Removal	Turn Valves
Filter Removal	Ultrasonic Inspection
Material Sectioning and Removal	Vacuuming
Surface Decontamination with High Pressure Spray	
Radioactive Material Handling and Transport	

Explosive Ordnance Disposal

Explosive Material Sensing	X-Ray
Explosive Defusing	Material Removal
Visual Surveillance	Sniper Surveillance

Mining

Roof Bolt Emplacement	Roof Support
Remote Mining	

Fire Fighting

Spray Direction	Smoke Detection
Flame Detection	

Security

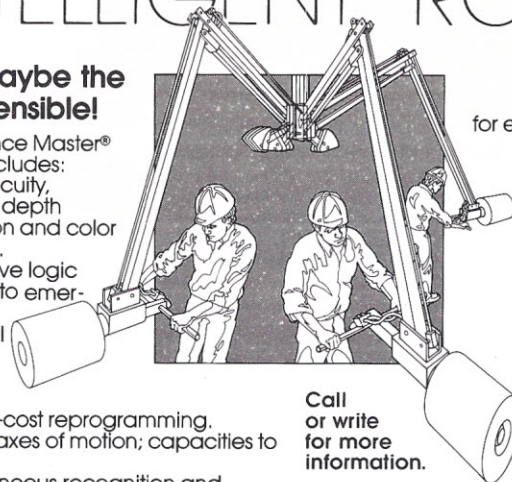
Personnel Detection	Breach of Security
General Patrolling	

The Conco Balance Master:[®] THE WORLD'S MOST INTELLIGENT "ROBOT"...

and maybe the most sensible!

The Balance Master[®] System includes:

- Visual acuity, including depth perception and color resolution.
- Deductive logic response to emergencies.
- No initial programming costs and instant no-cost reprogramming.
- Up to 7 axes of motion; capacities to 1,700 lbs.
- Instantaneous recognition and correction of production line problems.



Call
or write
for more
information.

- Low cost tooling and flexible design for ease of task/location modification.
- Simple, low cost installation — immediate start-up.

For more information on the Conco Balance Master System, circle the reader service number below, or write: Industrial Manipulator, Conco-Tellus, an Interlake Company, Mendota, IL 61342.

Phone 815/539-3450. TWX 910/642-1733.

CONCO-TELLUS
An Interlake Company

Dealer
Inquiries
Invited

Photo 8. The HAZCAT M100, Robotic Systems International, Ltd., Sidney, B.C., Canada, was designed to safely transport hazardous materials.

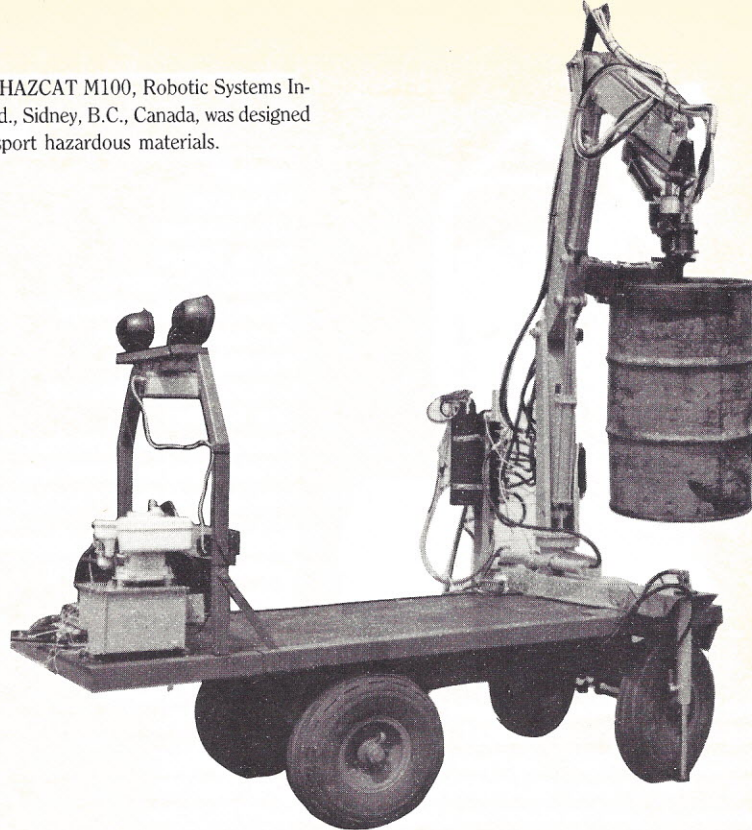
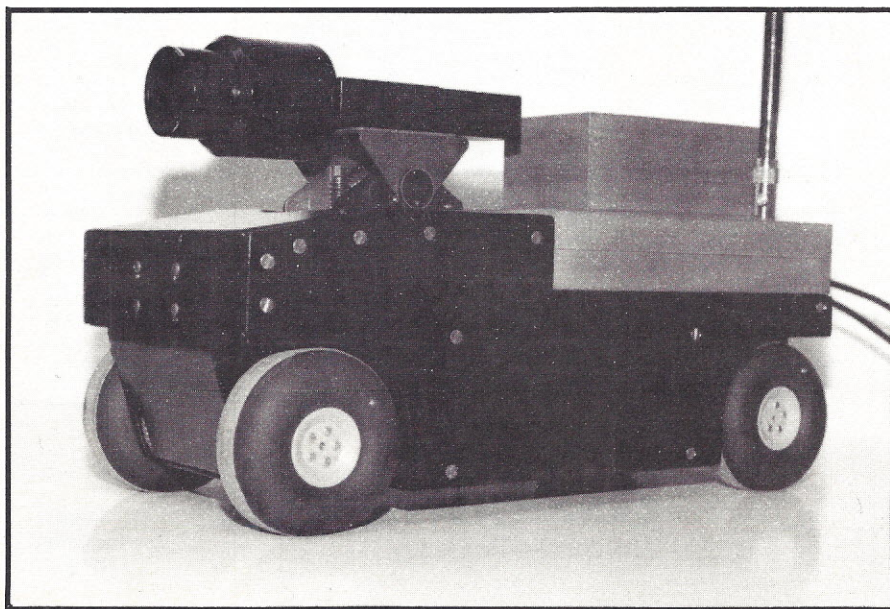
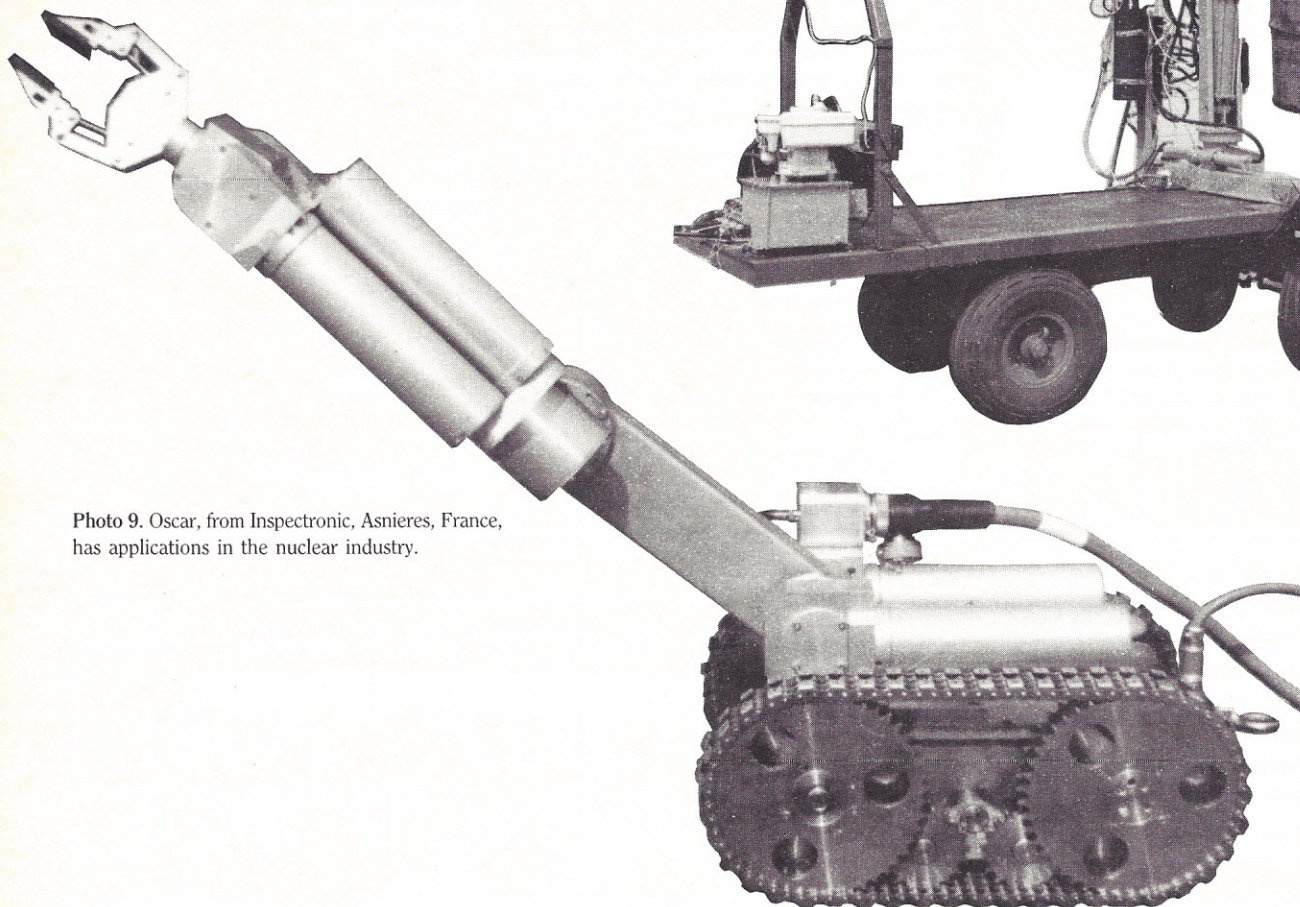


Photo 9. Oscar, from Inspectronic, Asnieres, France, has applications in the nuclear industry.



ment. Some vehicles were designed to operate only outdoors and others indoors. A few were designed to operate in both settings.

An examination of the specific missions T/Rs have carried out, or have been designed to carry out, for each of their respective industries (Table 3) indicates that many operations can be completed by any of several vehicles. Furthermore, the same or similar sensory and equipment package components can be found on most vehicles (Table 4).

Although mobile T/R vehicles have been under development for more than 20

Photo 10. The Miniocomp, Battelle Columbus Laboratories, Columbus, OH, performs general surveillance functions.

years, their basic external configurations have not undergone major modifications. There have, however, been significant improvements to the internals of the newer units. Systems are now being designed with modularity in mind, permitting individual components to be replaced on the vehicles. Modularity also facilitates the assembly of several vehicles from one common design, as exemplified in Photos 1 and 7.

PHYSICAL CHARACTERISTICS

The on-board sensors and tools depend on the mission assignments and the location of the work station. The sensor most commonly carried is the video (or CCD) camera. Although most units carry only one camera, some carry up to four and several employ pairs of cameras that offer the teleoperator a three-dimensional stereo image of the work environment, as,

for example the SURVEYOR, ATOM, Containment Vessel Robot, and HUNTER robots.

Very few of the current generation of mobile T/R vehicles possess any degree of intelligence. Most are directed by the teleoperator and do not have the opportunity to conduct preprogrammed missions. Microcomputers and/or microprocessors control a few functions on only a handful of vehicles, such as the ATOM and the TELEMAT (Photo 2) for arm movements, the ODEX for leg movements, the REMOTEBORE for drilling of core samples, the SURVEYOR for machine diagnostics, the PROWLER (Photo 3) for autonomous navigation within a known location, and the DCR for control of the dust-cleaning operations in ducts. Only four vehicles possess two robotic arms: the MARAUDER, the TELEMAT, the MF-3, and a device being developed by NTG Nukleartechnik, GmbH.

Table 4
Sensors and Applications

	Nuclear	Civil Ordnance	Security	Military Ordnance Recon.	Fire Fight	Mining
Autonomous Navigation	•	•	•	•	•	•
Biological Detection		•		•		
Chemical Detection		•		•		•
Collision Avoidance	•	•	•	•	•	•
Explosive Ordnance Detection		•		•		
Gas Detection	•	•	•	•	•	•
Heat Source	•	•	•	•	•	•
Humidity Detection	•	•		•	•	•
Laser - Application Detection	• •	• •	• •	• •		• •
Manipulate Loads						
Light (0-11 lb.)	•	•		•		
Moderate (11-55 lb.)	•	•		•		•
Heavy (> 55 lb.)	•	•		•	•	•
Object Detection						
Animate		•	•	•		•
Inanimate	•	•	•	•	•	•
Radiation Detection						
Infrared	•	•	•	•		
Nuclear	•	•		•		
Ultraviolet	•	•		•		
Smoke Detection	•	•	•	•	•	•
Sound - Projection Source Detection	•	•	•	•	•	•
Temperature	•	•	•	•	•	•
Vibration Detection	•	•	•	•		•
Vision - Video CCD Machine	• • •	• • •	• • •	• • •	• • •	• • •
X-Ray Analysis	•	•		•		

Circle 50

Write it once!

MasterFORTH

Portable programming environment



Whether you program on the **Macintosh**, the **IBM PC**, an **Apple II** series, a **CP/M** system, or the **Commodore 64**, your program will run unchanged on all the rest.

If you write for yourself, MasterFORTH will protect



your investment. If you write for others, it will expand your marketplace.

MasterFORTH is a state-of-the-art implementation of the Forth computer language.



Forth is interactive - you have immediate feedback as you program, every step of the way. Forth is fast, too, and you can use its built-in macro

CP/M faster. MasterFORTH's relocatable utilities,

transient definitions, and headerless code let you pack a lot more program into your memory. The resident debugger lets you decompile, breakpoint, and trace your way through most programming problems. A string package, file interface, and full screen editor are all standard features. And the optional target compiler lets you optimize your application for virtually any programming environment.

MasterFORTH exactly matches the Forth-83 Standard dialect described in *Mastering Forth* by Anderson and Tracy (Brady, 1984). The standard package includes the book and over 100 pages of supplementary documentation.

MasterFORTH standard package

Macintosh	\$125
IBM PC family (MS DOS 2.1).....	125
Apple II family (DOS 3.3)	125
CP/M 2.x (IBM 3740 8").....	125
Commodore 64 (with graphics)...	100

Extensions

Software Floating Point.....	\$60
Hardware (8087) Floating Point ...	60
Graphics (selected systems).....	60
Relocator (with utility sources)....	60
Target compiler (RAM and ROM) ...	350
Target Application Generation System (TAGS) - MasterFORTH, Target compiler & relocater.....	495

Publications

Printed source listings (each) ...	\$35
Forth-83 International Standard ...	18

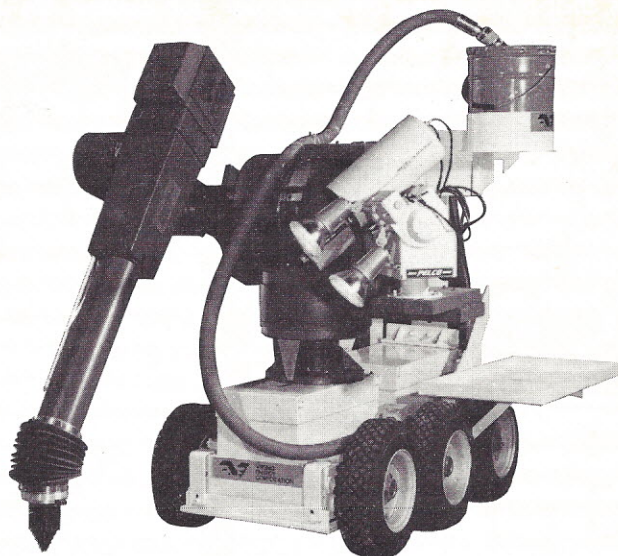
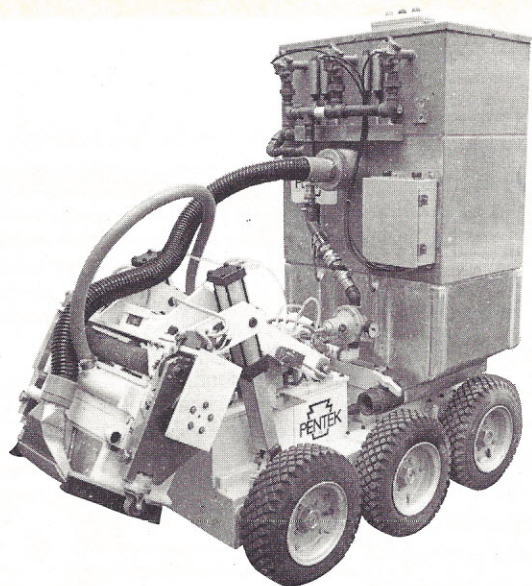
NEW PRODUCTS

MODEL List Processor.....	\$40
(with ELIZA and micro-LISP)	



MICROMOTION

8726 S. Sepulveda Bl., #A171
Los Angeles, CA 90045
(213) 821-4340



**Table 5
Specifications
(Generic Robot)**

	Small	Medium	Large
Locomotion (1)	2T	2T/4W/6W/6L	2T/4W/6W
Dimensions (in.) (l x w x h)	30 x 29 x 24	40 x 29 x 30	60 x 40 x 36
Weight (lb.)	55	440	1543
Tether Status	None (Cable Op.)	None (Cable Op.)	None
Communications	RF	RF	RF
Data/Info Trans	RF	RF	RF
Power Supply	Battery	Battery	Gasoline
Duration of Uninterrupted Performance	5 hr	5 hr	5 hr
Manipulators/Arms/Booms Reach (ft)	3	5	8
Lift Capacity (lb.)	22	220	882
Number of Axes	4	6	6
Platform Carry Capacity (lb.)	55	440	880
Sensors/Equipment Package	1 Video	3 Video	3 Video
Microcomputer/ Microprocessors (2)	None-Loco None-Arm	Little-Loco Some-Arm	Some-Loco More-Arm
Mobility/Maneuverability Stairs	YES	YES	YES
Slopes (degrees)	45	45	45
Chasms (in.)	NO	10	30
Obstacle Height (in.)	2	6	10
Thru Water Depth (in.)	NO	6	12
Underwater	YES	YES	NO
Zero Turning Radius	?	YES	YES
Speed (mph)	1	3	10

Notes: (1) L = Legged
T = Tracked
W = Wheeled
(2) LOCO = Locomotion

Photos 11 and 12. Moose, Pentek Corp., Coraopolis (Pittsburgh), PA, (left) and ROD (Remotely Operated and Driven Robot), Viking Energy Corp., Pittsburgh, PA, were developed for use in nuclear power plants.

THE "GENEROBOT"

It is possible to create an optimum device that is a composite of the salient characteristics of all the mobile T/R robots examined. Each of the three sizes of generic robot, or Generobot, in Table 5 is a summary of the "best fit" robotic features and specifications for use in hazardous environments.

This article is based on a paper presented at "Artificial Intelligence & Robotics for the U.S. Army," a symposium sponsored by the American Defense Preparedness Association and held in Austin, Texas, last November.

Harvey B. Meieran is President of HB Meieran Associates, and Floyd E. Gelhaus is Manager, Reliability and Maintenance Technology for the Electric Power Research Institute (EPRI).

Reader Feedback

To rate this article, circle the appropriate number on the Reader Service card.

2	12	22
Excellent	Good	Fair

1,000 SENSOR PRODUCT SOURCES

The 1986 Sensor and Transducer Directory

Now you can locate nearly 1,000 suppliers of sensor and transducer products in a single publication. The 1986 *Sensor and Transducer Directory*, from the publishers of *Sensors* magazine, lists nearly 1,000 companies producing over 400 types of sensors and transducers. The 1986 *Sensor and Transducer Directory* provides a comprehensive list of suppliers for each sensor category. Each company listing includes the company address, key personnel, and the sensor and transducer products available. For further information, an optional company/product line profile is also provided.

If you're looking for sensors, don't waste valuable time paging through catalogs and spec sheets. Join the thousands who have sensor sources at their fingertips—in the 1986 *Sensor and Transducer Directory*. Order yours today!

ONLY \$49.95

☐ Please send _____ copies of the 1986 *Sensor and Transducer Directory* at \$49.95 in the U.S., \$51.95* in Canada, or \$59.95* other foreign countries (includes postage and handling costs).

☐ Personal Check

☐ Bill Me PO# _____

☐ MasterCard

☐ Visa

Payment Enclosed \$ _____

☐ Cash

Expires _____

Account No. _____

Signature _____

Name _____

Company _____

Address _____

City _____

State _____

Zip _____

Send to **North American Technology** 174 Concord St., Peterborough, NH 03458 (603) 924-7261
*U.S. funds drawn on a U.S. bank

3/86 RE

Robotics Databases

Thomas W. Conkling

Pennsylvania State University
325 Hammond Building
University Park, PA 16802

Robotics is currently enjoying the attention of industry, the public, and government. As robotics research and development activity has increased, so has the number of technical publications in this field and related ones such as computer vision, artificial intelligence, sensors, and computer integrated manufacturing. Anyone who wants to keep up with developments and trends in a particular specialty is faced with the problem of selecting interesting papers from this growing body of technical information. On-line searching of robotics databases provides an effective means of doing this.

ON-LINE DATABASE SYSTEMS

Over 2800 databases are available from vendors in this country and in Europe (1). Vendors provide the software and the host computer on which the databases are maintained and the searches take place. In most cases, however, they are not involved in the production of databases. The vendors with files holding considerable robotics information are DIALOG Information Services (Palo Alto, California), BRS Information Technologies (Latham, New York), System Development Corporation (Santa Monica, California), and the European Space Agency Information Retrieval Service (Frascati, Italy).

Three major types of databases are available for searching: bibliographic, numeric, and full text. Bibliographic databases are the focus of this article since they contain a wealth of robotics data. These databases

are collections of bibliographic references in particular fields of knowledge. Each database record commonly includes the author's name, title of the article or report, name of the journal or conference, and publication data such as volume, page, and date. Often, records include abstracts that summarize the article's contents.

A broad range of technical literature is indexed in databases, with articles from scholarly and trade journals being most prevalent. Conference papers and technical reports make up a large portion of the on-line information, as do patents and standards. One category of literature that is not present in public data files is proprietary work done by corporations. Information about companies is available on line, but internal engineering reports and research findings are not normally accessible.

On-line searching is powerful because it allows you to browse through millions of references in minutes, retrieving those of interest. In this way, you can monitor advances in engineering and science and avoid duplication of research effort. Searches are done interactively using a terminal or microcomputer and a modem.

Searches are based on the retrieval of records containing key words or combinations of key words. For example, to find several recent articles on actuators for robots, a user can log on to the COMPENDEX database and enter the search terms as shown in Listing 1. Both terms are entered in truncated form to pick up variant spellings such as robots, robotics,

and actuators. The results show that 3639 records contained "robot?", 1460 contained "actuator?", and 87 contained both terms. The first four articles from the last set are listed in the basic display format. Additional terms could be entered and manipulated with Boolean operators (AND, OR, and NOT) to further refine the results. This sample search took 2 minutes and cost under \$5.

ROBOTICS DATABASES

Robotics information is spread throughout a number of databases. Valuable data can be located in any of the files described below, but a search may demand that a combination of files be used. A problem encountered when searching multiple files is duplication of results, which occurs because many of the same publications are indexed by different databases. However, this is a minor difficulty and does not interfere with search success.

The largest database dedicated to robotics is *Robotics Information* (BRS). This file is comparatively small as on-line databases go (i.e., less than 11,000 records), but it contains few peripheral papers. Cincinnati Milacron began building this file in the late 1970s and recently sold it to EIC/Intelligence, Inc. The file spans from 1980 to the present, with selected references to 1970. Approximately 250 journals are scanned each month for relevant material, as are numerous conferences, technical reports, and books. The database is international in scope,

with papers on all aspects of robotics. A robotics file of comparable size is *Robomatix* (ESA/IRS), which is also produced by EIC/Intelligence. This database has a counterpart in print titled *Robomatix Reporter*, a monthly abstract service. A variety of international publications are indexed, and the file covers from 1973 to the present. Both *Robomatix* and *Robotics Information* are updated on a monthly basis.

The most comprehensive engineering database in terms of breadth of coverage and time span is *Compendex* (DIALOG, BRS, SDC, ESA/IRS), a product of Engineering Information, Inc. It exists in a printed form as the well-known monthly abstracting journal *Engineering Index*. This file contains almost 1.5 million references to published works in engineering and related disciplines. Its coverage of the technical aspects of robotics is excellent. Over 2500 journals are scanned monthly, and other sources such as conference proceedings, books, and technical reports are also indexed. The database reviews the international literature from 1970 to the present. *EI Engineering Meetings* (DIALOG, SDC, ESA/IRS), a companion file to *COMPENDEX*, went on line in 1982 to supply increased coverage of the world's engineering conference literature.

Federal agencies such as the National Aeronautics and Space Administration, the Department of Defense, and the National Science Foundation have long had an interest in robotics applications. Results from the research they sponsor at universities, laboratories, and companies are often issued as technical reports. *NTIS* (DIALOG, BRS, SDC, ESA/IRS) is a large database produced by the Department of Commerce. It contains records of virtually all unclassified technical reports issued as a result of government-sponsored research since 1964. Searching this file is useful because most of the reports and data it contains are not published elsewhere.

Publications on image processing, microprocessors, and other areas of electrical engineering are indexed in *INSPEC* (DIALOG, BRS, SDC, ESA/IRS). This database is a product of the Institution of Electrical Engineers and is a fine source of information in electronics, computers, and physics. *INSPEC* dates from 1969 and is worldwide in scope, with particularly

strong coverage of European research. Over 2.4 million records make up the database.

The Society of Manufacturing Engineers (SME) maintains a database called *IN-TIME*, which contains records of most SME technical papers and journal articles published since 1974. The database is noteworthy because members of this society are intimately involved with applications of robotics and advanced manufacturing technologies. Although this file is not at present available for public on-line access, searches can be ordered through SME. Rates charged for searches are competitive with those of other on-line systems.

The world's patents are covered extensively in on-line files. Using a combination of databases, it is possible to perform a patent search retrospectively to 1950 for U.S. patents and to 1974 (or 1963 selectively)

for foreign patents. Patent databases can usually be searched by classification codes, assignee, inventor, cited patents, and key words from titles and abstracts.

Robotronics Age Newsletter is an example of a full-text database. It is an electronic newsletter, published 26 times annually, and it does not exist in a printed version. *Robotronics* gathers news and information from a number of sources to provide current coverage of developments in robotics. The complete text of the newsletter is on line for browsing or printing. *Robotronics* and similar news-oriented files are available through NewsNet (Bryn Mawr, Pennsylvania).

Other technical databases are available to the robotics specialist, including ones covering engineering software and military and industrial standards. The business and management aspects of robotics can also

Listing 1 A subject search on actuators for robots in the COMPENDEX database on DIALOG

FILE8:COMPENDEX - 70-85/May
Copr. Engineering Information Inc.)

	Set	Items	Description
? SS ACTUATOR? AND ROBOT?			
	1	1460	ACTUATOR?
	2	3639	ROBOT?
	3	87	1 AND 2
? T3/3/1-4			
3/3/1			
1709381	EI8505039381		
	DESIGN OF SELF-CENTRING SEAL-LESS HYDRAULIC PISTONS.		
	Laurenson, I.T. Ulster Polytechnic, Newtownabbey, North Irel		
	Proc Inst Mech Eng Part B v 199 n B1 1985 p 59-65 CODEN: MEMAEM ISSN:		
	0263-7146		
	Languages: ENGLISH		
3/3/2			
1708122	EI8505038122		
	ALGORITHM FOR PLANNING OF MANIPULATOR TRAJECTORIES IN THE PRESENCE OF		
	OBSTACLES.		
	Generozov, V.L.		
	Eng Cybern v 22 n 2 Mar-Apr 1984 p 83-92 CODEN: ENCYCAF ISSN:0013-788x		
	Languages: ENGLISH		
3/3/3			
1705465	EI8505035465		
	ELECTRIC VERSUS HYDRAULIC DRIVES.		
	Anon.		
	Inst. of Mechanical Engineers, London, Engl		
	I Mech E Conf Publ 1983-13, Electr Versus Hydraul Drives, London, Eng,		
	Oct 27 1983. Publ by Mechanical Engineering Publ Ltd, Bury St. Edmunds		
	for Inst of Mechanical Engineers, London, Engl, 1983 90p CODEN: IMEPD4		
	Languages[ENGLISH		
3/3/4			
1701244	EI8504031244		
	COMPUTER-AIDED DESIGN OF A LEG FOR AN ENERGY EFFICIENT WALKING MACHINE		
	Song, S.M.; Vohnout, V.J.; Waldron, K.J.; Kinzel, G.L.		
	Ohio State Univ, Dep of Mechanical Engineering, Columbus, OH, USA		
	Mech Mach Theory v 19 n 1 1984, Appl Mech: 7th OSU Conf, Kansas City,		
	MO, USA, Dec 7-9 1981 p 17-24 CODEN: MHMTAS ISSN: 0374-1052		
	Languages[ENGLISH		

be researched on line. *Dun's Market Identifiers* (DIALOG) contains marketing, product, and financial information on some 2 million companies. *Predicasts* (DIALOG, BRS) has databases covering economic and business forecasts, market data, defense industry contracts, and corporate news and developments. Articles on management techniques, operations research, and organizational matters are indexed in *Management Contents* (DIALOG, BRS, SDC). These files represent only a sampling of the sources currently on line. For a comprehensive listing that is updated periodically, consult a directory such as the one by Cuadra Associates (2).

SEARCH OPTIONS

Database access options are quite varied. The on-line industry has recently shifted its marketing efforts toward the end user, i.e., the engineer or scientist who needs the information. Throughout the 1970s, intermediaries, such as technical librarians, did most of the searching for end users. Now, developments have made

On-line searching is powerful because it allows you to browse through millions of references in minutes... You can monitor advances in science and engineering and avoid duplication of research effort.

it feasible for researchers themselves to search effectively with little or no training.

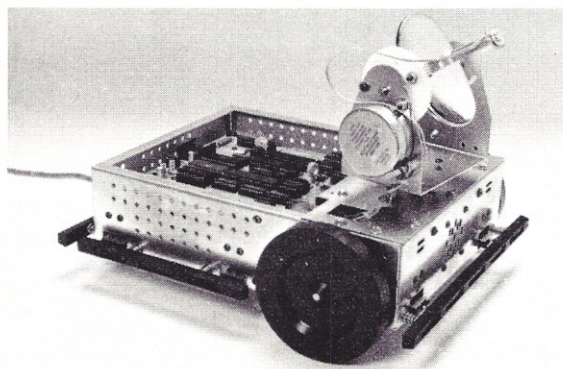
All vendors have their own standard search systems with a query language, access protocols, database royalty charges, and connect-time rates that vary between files. Some systems operate on a pay-as-you-go basis, while others have additional monthly or annual fees. Most vendors offer system manuals and training seminars, and users must register with them to begin service. As noted earlier, the equipment needs for searching are basic—a terminal or microcomputer, a modem (300 or 1200 bps), and a phone line.

As an alternative to the standard service,

BRS and DIALOG have developed systems for use during nonbusiness hours—BRS After Hours and Knowledge Index, respectively. These systems, which operate in the evenings and on weekends, offer some of the same engineering and business files as the daytime services. What these systems provide are simplified search procedures and lower rates. After obtaining a password, an untrained user can log on and perform a productive search with little difficulty. BRS has recently introduced BRKTHRU, a menu-driven search system that can be used during regular business hours or in the off hours. Standard access rates are charged during the day and discount rates apply at other times.

Software packages have been written for microcomputers that facilitate the search process. A typical program can automatically dial the vendor and log on to the system. Some packages permit the searcher to enter the search strategy before log on, thus lowering connect-time costs. The software may use a modified version of the query language or guide search strategy development with menu screens. Results can be easily downloaded to disk for later manipulation or printing. This front-end

LIMITED TIME SPECIAL OFFER: SCORPION MOBILE ROBOT KIT



World leaders in instructional robotics

RHINO
R O B O T S

3402 N. Mattis Ave.
P.O. Box 4010
Champaign, IL 61820
(217)352-8485

Originally \$660
NOW ONLY \$299*
SAVE OVER 50%

**FACTORY
DIRECT
ONLY**

The package price gives you the Scorpion kit with everything needed for assembly plus our 250-page assembly and operation manual (a \$20 value) as a free bonus.

The Scorpion is a versatile floor mobile robot that can be run from the RS-232C port of any computer, small or large. It is designed specifically for the serious robotic enthusiast who owns a personal computer and would like to experiment with robotics, artificial intelligence, machine intelligence, pattern recognition, and mobile robot theory. These activities are permitted by the Scorpion by virtue of its unique features, which include 2 drive motors, 4 bumpers with 2 microswitches each, 2 programmable eyes, a speaker with tone and duration programmability, a 2 axis optical scanner that allows patterns of the brightness of the robot's environment to be displayed on the CRT of the computer, and a 2 phase floor scanner that can be used to allow the Scorpion to track the floor environment in an intelligent manner.

Enclose check or money order with order. VISA or Mastercard charges accepted. *Power supply not included. Shipping extra.

software is designed to search either a particular vendor system or on multiple systems. Most packages run on IBM PCs or compatibles, with a smaller selection available for other micros. Some packages currently on the market are In-Search (Menlo Corporation), Instantcom (Instant Information), PC/Net Link (Information General), and Sci-Mate (Institute for Scientific Information).

An innovative system called EasyNet promises the simplest on-line access yet for untrained searchers. EasyNet acts as a user's gateway to major database vendors (DIALOG, BRS, SDC, and NewsNet included), which collectively maintain hundreds of files. EasyNet is accessed by dialing a toll-free number, and billing is done by credit card account. Once logged on, the user is assisted in developing the search by a series of menu screens. The user can specify a database or let EasyNet make the choice. The search is automatically run on the chosen database, and a small number of recent references are displayed for the searcher. The fee is low for each such usage (under \$10), but charges increase for additional references and searches.

Searching is economical both in terms of time and money, especially when compared with manually gathering the same information. Search costs vary greatly depending upon the vendor, databases used, connect time, and number of references printed. Most searches cost between \$10 and \$75, but the price can go much higher for comprehensive searches on expensive files. The time required to do a search is minimal. Quick reference searches can be done in a couple of minutes, and a complex search may take no more than 15 or 20 minutes.

ON-LINE ORDERING

By their very nature, bibliographic searches leave the user one step away from the needed information, i.e., the references are in hand but not the actual documents. Several database vendors have on-line ordering capabilities that make it possible to order copies of almost any document retrieved in a search. A number of commercial information suppliers are involved in this program, including some on-line database producers. Using these suppliers, most articles and papers can be ob-

tained for under \$15.

Current awareness services are available on various search systems. These systems, called selective dissemination of information, or SDIs, consist of detailed searches, tailored to an individual's subject needs and stored on the vendor's computer. These SDIs are run each time a new update tape is loaded, and any references retrieved are mailed to the user. Costs are reasonable, making SDIs a convenient way to periodically review developments in robotics and other fields.

REFERENCES

1. Williams, M.E. *Computer-Readable Databases: A Directory and Data Sourcebook*. (Chicago, IL: American Library Association, 1985).
2. Cuadra Associates, Inc. *Directory of Online Databases*, v. 6. (Santa Monica, CA: Cuadra Associates, 1985).

Thomas W. Conkling is Head of the Engineering Library at Pennsylvania State University.

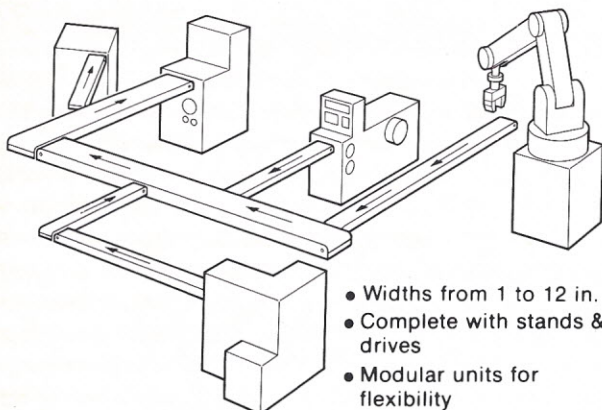
Reader Feedback

To rate this article, circle the appropriate number on the Reader Service card.

3	13	23
Excellent	Good	Fair

DORNER CUSTOM PRODUCTION LINE CONVEYING SYSTEMS

For complete automation of small product production. Conveyor lines from 2 to 2,000 ft.



- Widths from 1 to 12 in.
- Complete with stands & drives
- Modular units for flexibility
- Engineering assistance available

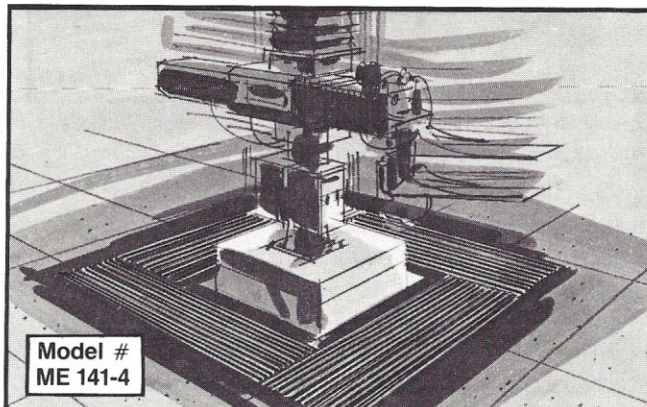
DORNER
MFG. CORP.

580 Industrial Drive
Hartland, WI 53029
414/367-7600

SEE OUR CATALOG IN
THOMCAT
THOMAS REGISTER CATALOG FILE

DM-44R2

Circle 51



GuardianMat Safety Switch

protects lives & equipment



MillerEdge

Visit us at
Robots 10 Booth #1060

- Failsafe construction for total reliability
- 100% flexible to withstand impact & resist damage
- Custom sizes & shapes to your exact specs
- Heavy duty non-skid surface resists common greases & oils

Call MillerEdge for free sample.

Concord Industrial Park, P.O. Box 38, Concordville, PA 19331
(215) 459-4241

Robotic and Remotely Operated Technology in Hazardous Waste Sites

Eugene B. Silverman, Ph.D.

ARD Corporation
5457 Twin Knolls Road, Suite 400
Columbia, MD 21045

Robotics and remote handling technology have seen significant advances in recent years. Industry is today beginning to seriously investigate and apply these technologies to monitoring, surveillance, and waste handling tasks in hazardous environments. In commercial nuclear power plants and fuel processing facilities, robots and remotely operated tools are being used to help reduce the amount of personnel exposure to radiation. These devices can be used also to address hazards associated with toxic waste material collection, processing, storage, handling, transportation, and disposal, site monitoring and characterization, and material analysis and handling. Robots can increase personnel safety, improve site maintenance and cleanup, and reduce the costs of such operations.

THE IRIS SURVEYOR MOBILE SURVEILLANCE SYSTEM

Originally targeted for the nuclear power industry to reduce personnel exposure to radiation, the IRIS® Surveyor™ Mobile Surveillance System has found applications in other environments that require on-site visual inspection and environment definition. The Surveyor supplements the human operator in dark, dirty, and dangerous places, working at such tasks as nuclear power plant surveillance; chemical and petroleum plant inspection and surveillance; hazardous waste storage area inspection and sampling; industrial accident investigation and characterization (e.g., chemical spills in plants and storage areas, and from truck and train wrecks); and industrial security (indoor autonomous patrol and automatic alarm).

Robotic Vehicle. The Surveyor moves at speeds of up to 1 ft/sec. It is designed to avoid obstacles, wade through water up to 6 in. deep, climb 45 degree stairs (Photo 1), and maneuver through doors, halls, and labyrinthine paths. It requires less than a 34-in. vertical clearance. The modular design incorporates basic building blocks that can be reconfigured for a variety of applications. These blocks include the propulsion subsystem, payload deck, electronics, stereoptics, inspection optics, robotic arm, telescoping arm (optional), and sensors. With all systems "on," the vehicle can operate up to four hours between recharges. The Surveyor weighs 300-350 lb. (depending on



Photo 1. Tracks allow the Surveyor to climb a 45 degree set of stairs.

payload), and measures 45 in. long by 22 in. wide by 20 in. high (top of oven deck). It has a payload capacity of 250 lb.

Supervisory Control Station. The Surveyor control station (Photo 2) is a portable, rugged, computer-based command center that can be easily positioned in places throughout any facility; all systems can be on line within a few minutes. The operator uses the system to position the remote vehicle and manipulate the inspection optics and the smear sampler. Vehicle status (elapsed time, battery use and remaining life, sensor position, etc.) can be displayed on command or, in an emergency situation, automatically. Acquired data such as radiation and temperature are formatted and displayed to provide instantaneous readings and time histories. The computer that formats this digital data for display to the operator also stores the information for subsequent analysis.

The major console components include two high-resolution black and white monitors that, along with a three-dimensional hood, provide the operator with a clear 3-D picture of the view in front of the vehicle for precise maneuvering. At operator command, the monitors show the inspection optics display (left monitor) and environmental and vehicle status data (right

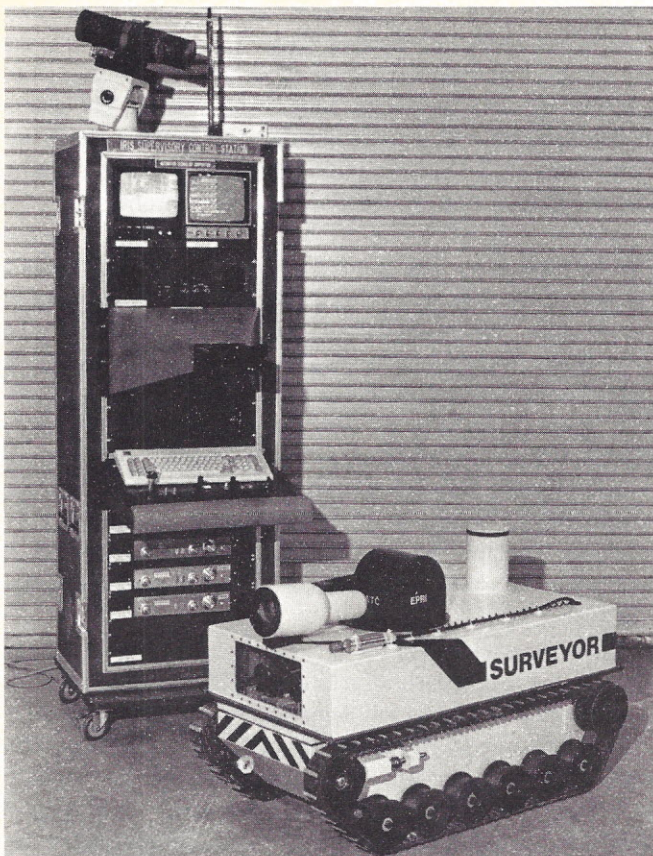


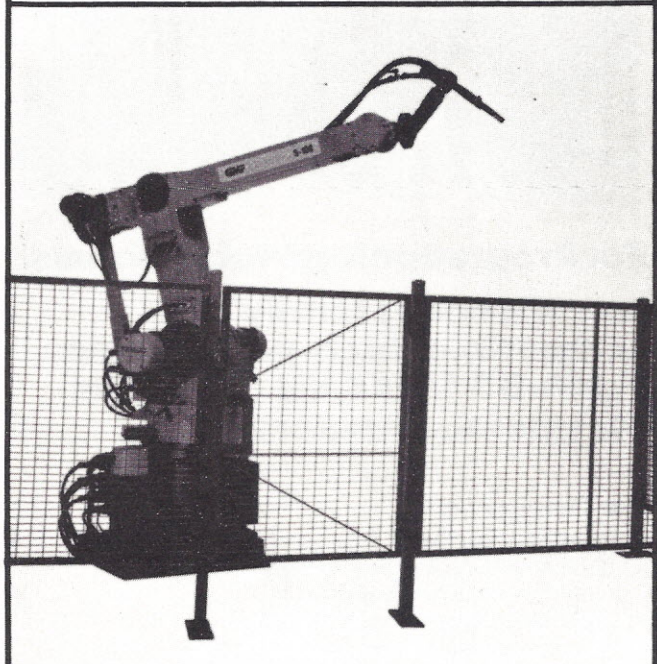
Photo 2. The Surveyor is shown with its supervisory control station the operator can use to control the vehicle and monitor acquired data.

monitor). An auditory display system provides real-time, binaural, on-site sound "pictures" for telepresent auditory localization.

Three-Dimensional Viewing System. Remote stereoptic viewing greatly enhances operator depth judgement and control, and increases speed and accuracy of operation. Other stereoptic advantages over traditional vision systems include enhanced image interpretation and resolution, increased visual field size, and detection of binocular luster and scintillation. These advantages are of particular assistance under conditions of low illumination, in situations where actual depth differences are small, and where there is a need for the resolution of complex and/or unfamiliar environments.

The standard Surveyor camera system consists of matched black and white CCD cameras mounted in tandem. The cameras are adjustable and can be configured to meet a wide variety of operating requirements. Other types of cameras, including color, can also be used. In a standard arrangement, 9-in. (diagonal) black and white monitors are stereoscopically converged via a matching stereoptic swingaway, rack-mountable, optical viewing hood that allows stereo viewing without additional goggles, glasses, or filters; operators can view the display while using their own optical corrections. A user-friendly computerized alignment procedure permits the operator to adjust system brightness, contrast, and screen display location. The Surveyor inspection optics subsystem is a dynamic and flexible remote video surveillance device capable of both telescopic close-up and wide-angle viewing over a large range of illumination levels. A zoom lens allows the operator to select and focus in

ROBOT GUARDS



Woven wire mesh panels bolt to steel posts with standard hardware to make strong, effective robot guards

☆ **Cost Effective**

Beats prices of electronic systems

☆ **Uninterrupted guarding**

Not subject to power failures

☆ **Defines Work Envelope**

Keeps objects inside work envelope

☆ **Easy to Relocate**

Modular posts not sunk into plant floor

☆ **Options Available**

Meshes 1/2", 1", 2" x 1", sheetmetal

WIRE CRAFTERS INC.

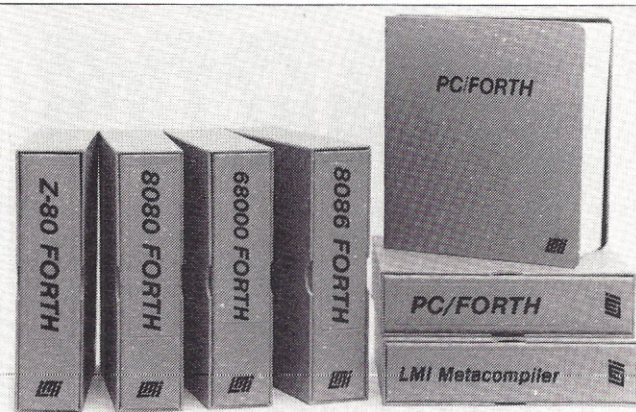
Box 14187

Louisville, KY 40214

502 363-6691

1-800-626-1816

TOTAL CONTROL with LMI FORTH™



For Programming Professionals: an expanding family of compatible, high-performance, Forth-83 Standard compilers for microcomputers

For Development:

Interactive Forth-83 Interpreter/Compilers

- 16-bit and 32-bit implementations
- Full screen editor and assembler
- Uses standard operating system files
- 400 page manual written in plain English
- Options include software floating point, arithmetic coprocessor support, symbolic debugger, native code compilers, and graphics support

For Applications: Forth-83 Metacompiler

- Unique table-driven multi-pass Forth compiler
- Compiles compact ROMable or disk-based applications
- Excellent error handling
- Produces headerless code, compiles from intermediate states, and performs conditional compilation
- Cross-compiles to 8080, Z-80, 8086, 68000, and 6502
- No license fee or royalty for compiled applications

Support Services for registered users:

- Technical Assistance Hotline
- Periodic newsletters and low-cost updates
- Bulletin Board System

Call or write for detailed product information and prices. Consulting and Educational Services available by special arrangement.

LMI Laboratory Microsystems Incorporated
Post Office Box 10430, Marina del Rey, CA 90295
Phone credit card orders to: (213) 306-7412

Overseas Distributors.

Germany: Forth-Systeme Angelika Flesch, D-7820 Titisee-Neustadt
UK: System Science Ltd., London EC1A 9JX
France: Micro-Sigma S.A.R.L., 75008 Paris
Japan: Southern Pacific Ltd., Yokohama 220
Australia: Wave-onic Associates, 6107 Wilson, W.A.

fields of view from 5.5 to 55 degrees (diagonal); the operator can read gauges and position indicators and inspect for leaks and cracks. Adjustment for different luminance levels takes place automatically via a quick-responding auto-iris system. The system is shock-mounted in a watertight housing to ensure effective operation and ease of cleanup/decontamination after operating in toxic, radioactive, or chemically harsh environments.

The Robotic Arm. The arm is a precision device that permits the remote operator to accurately aim the inspection optics and to measure the positions of the Tele-Sampler and the manipulator. It carries an optional variety of sensors, along with inspection optics and smear samples. The arm can pick up objects weighing up to 5 lb. and can operate switches. Three degrees of freedom are provided for optics and four degrees of freedom for the Auto-Telesampler. By adding the manipulator, which includes a wrist, a total of six degrees of movement are available. The arm can reach to floor level and to a height of nearly 6 ft. An arm capable of lifting 50 lb. will be available later this year.

The waste sampler on the arm can be positioned to obtain samples not readily accessible to the on-site technician. Sensor outputs, including radiation, temperature, and relative humidity, are continuously transmitted from the vehicle and are processed and displayed on the console. Noise sensors monitor equipment and system performance. Graphical representation is available for subsequent analysis. Vehicle operating subsystem status data is processed and displayed in real time on the color data monitor. The optional telescoping arm can reach up to 15 ft from its stored position. It is extremely rugged and operates efficiently in harsh environments such as high-temperature and -humidity atmospheres and high-radiation fields. It can be installed on either fixed stations or mobile platforms.

Other subsystems as well can be used on different bases. The stereoptic vision and the communication systems have been combined into a product called Comvu that provides telepresence for use on other remotely operated vehicles for any application which requires that solid smear samples be obtained and automatically packaged. The Tele-Sampler can be mounted on an extension and used in any situation that requires the collection of solid particle samples. The product evolution also includes a capability for liquid sampling.

CONCLUSION

Robots can be sent into dark, dirty, and hazardous environments to gather data the human operator can use to make informed decisions. Investigating situations and solving problems via a robot/operator collaboration results in both human safety and accuracy of reported details. Finally, both the robot and the operator wind up doing the work appropriate to each.

Eugene B. Silverman is President of ARD Corporation.

Reader Feedback

To rate this article, circle the appropriate number on the Reader Service card.

4	14	24
Excellent	Good	Fair

In The Robotics Age™

Edited by Stephanie vL Henkel

MARKET RESEARCH

Manufacturers' sales of automated storage and retrieval systems will top \$1 billion by 1994, according to a new study from **Business Trend Analysts**. The estimate for 1985 is given at \$253 million. Rapid advances in computer controlled technology are changing the material handling equipment industry picture, dictating a flurry of corporate acquisitions and divestitures and prompting a reorganization of the industrial workplace, the report continues. The wave of the future will be the expanded development of automatic guided vehicles running on wires embedded in the factory floor, BTA says.

Overseas manufacturers have gained the balance of trade advantage in capital equipment markets since 1980. In material handling equipment, for example, the U.S. trade balance swung from a \$373.3 million surplus to a \$453.3 million deficit. Material handling imports grew 84.5 percent in 1984 alone, while exports fell to 6.3 percent. U.S. imports of material handling equipment were \$853.1 million in 1984, representing 15.4 percent of apparent consumption. The greatest impact on the domestic market came from industrial trucks and tractors.

CORPORATE NEWS

► **SMI, Colorado, Inc.** is a newly formed distributor of flexible automation products in Colorado, New Mexico, Utah, and Wyoming. SMI offers application assistance and local inventory in microstepper motors and positioning systems, DC servo motors, gear motors, speed controls, rotary and linear position transducers, rotary and linear stages, vision systems, flexible couplings, PWM amplifiers, programmable motion controllers, and robotics. The firm is at 141 W. Davies Ave., Suite 100, Littleton, CO 80120, telephone (303) 794-7975.

► **Kurzweil Applied In-**

telligence, Inc. has announced a joint agreement with **FutureNet Corporation** to develop specific electronic engineering vocabularies and software commands linking its DASH workstations for voice control with the KVS, a speech recognition peripheral that enables users to use spoken commands to run IBM PC-AT, PC-XT, and PC AT/XT-compatible computers. FutureNet will promote the KVS to its DASH distributors, sales representatives, and customers, and will refer all sales leads to Kurzweil. In exchange, Kurzweil will promote the voice link to DASH products and refer sales leads to FutureNet.

► **Hudson Robotics, Inc.** has been awarded a contract by **Exxon Corp.** to develop a robotic workcell for automating solution viscosity measurements. The system uses a Mitsubishi Movemaster RM-105 robot interfaced to a Schott AVS II-B intrinsic viscometer. The workcell is a complete, computer controlled station, including automatic loading, testing, and unloading of vials, beakers, or other types of containers required for a particular job. It is expected to reduce worker exposure to hazardous solvents, improve overall testing results, and allow continuous test runs overnight and during week-ends.

► **Itran™ Corporation**, a supplier of machine vision systems, has announced receiving over \$3 million in a recent round of financing. Prior investors, as well as new ones, participated, with Morgan Holland Ventures Corp. taking the lead. Itran's president, Stanley N. Lapidus, said the funds would be used to expand the firm's development, production, and marketing activities.

► **Machine Vision International** has received orders from **Ford Motor Company** for three-dimensional robotic guidance systems to be installed at three Ford plants. The total value of the contracts is \$1.3 million. The systems will be installed in two metal stamping plants and one plastic molding plant and will be used in material handling operations.

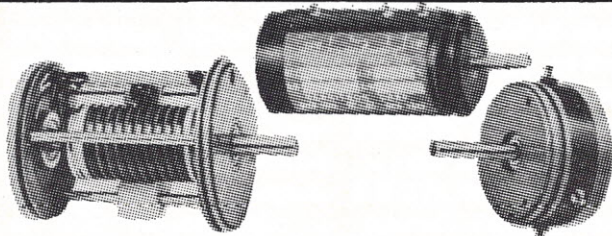
► **The Remington Arms Company**, a wholly owned sub-

sidary of E.I. du Pont de Nemours & Co., has ordered a large flexible manufacturing system from **Cincinnati Milacron**. The system, which will be used to produce metal components for sporting rifles and shotguns, is the first phase of a comprehensive plan to modernize the Remington Arms plant in Ilion, New York. The \$6.5 million first-phase contract with Cincinnati Milacron is for an FMS based on 10 Milacron T-10 CNC machining centers with automated systems for work changing, material handling, and chip removal. Completion of the FMS is scheduled for the end of the year.

► **Martin Industries**, the leading U.S. manufacturer of robotic systems for the plastics injection molding industry, has moved from Chicopee to new quarters in Agawam, Massachusetts. The move reunites the Chicopee and the Holyoke, Massachusetts, facilities, which were split in 1983 due to space requirements. In 1985 Martin bought the British firm, Robot Engineering, Ltd., now known as Martin Industries, Ltd., which manufactures and markets Martin robotic systems in Europe.

► **Interface Technology, Inc.** has moved into new offices at 14440 Cherry Lane Court in Laurel, Maryland. The firm has also announced the receipt of a contract from **ATR, Inc.** for the development of a robot vehicle for use in a major corporation's chip fabrication clean room. Interface has specialized in custom micro-computer systems integration

ROTARY SINGLE-TURN MULTI-TURN FILM POTENTIOMETERS



In offering this broad range of infinite resolution conductive film potentiometers, with their many standard and customized configurations, Vernitech continues to supply your industry with extremely reliable, long life products.



Call or write

VERNITECH

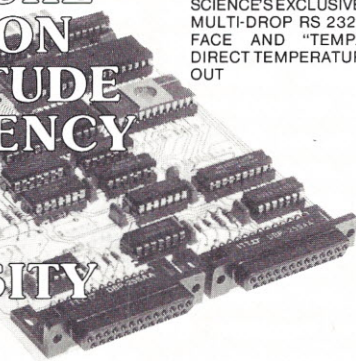
a division of Vernitron Corporation

300 Marcus Boulevard, Deer Park, N.Y. 11729
(516) 586-5100 / TWX 510-227-6079

THE SOFTWARE SCIENCE MICROTELEMETRY MODULE

TEMPERATURE
VOLTAGE
PRESSURE
POSITION
AMPLITUDE
FREQUENCY
LEVEL
ANGLE
INTENSITY
SPEED

8 CHANNEL ANALOG DATA ACQUISITION AND CONTROL SYSTEM WITH SOFTWARE SCIENCE'S EXCLUSIVE "SSNET" MULTI-DROP RS 232C INTERFACE AND "TEMPACHEAP" DIRECT TEMPERATURE READ-OUT



Your sensors and the Software Science Microtelemetry Module can put analog data and control at your computer or terminal's fingertips.

- 8 channels of 8 bit analog data, on demand, through any RS 232C interface
- 12 individually controllable digital output lines
- decimal ASCII commands and responses
- Select analog input, digital output, and formats under software control from RS 232C interface
- Formats for analog data include: raw data - voltage - temperature
- "TEMPACHEAP" direct temperature readout in F. or C. -10 to 160+ F. (sensors \$10.00 ea. or 8 for \$72.00)
- "SSNET" multiple unit RS 232C interface for networks of Microtelemetry Modules on one RS 232C interface

MICROTELEMETRY MODULE (MTM1).....\$249.00
assembled and tested 4.5 x 6.5 inch printed circuit board with complete installation and application documentation

(513) 561-2060

CALL OR WRITE
FOR TECHNICAL FLYER

**SOFTWARE
SCIENCE**

P.O. Box 44232,
Cincinnati, Ohio 45244

In The Robotics Age™

and is a recent arrival in the area of robot systems integration.

► **GMF Robotics Corp.** has broken ground for its new \$26 million world headquarters in Rochester Hills, Michigan. The 325,000 ft² complex is expected to be completed by late this year or early 1987. Most employees at the new facilities will be engineers and computer specialists, according to company president and CEO Eric Mittelstadt. GMF expects that number to grow to 2000 by the end of the decade. According to a November, 1985, report from Prudential-Bache Securities, estimated 1986 sales predictions for GMF are \$235 million, approximately one-third of the domestic industry's projected 1986 sales of \$690 million.

► **John Brown Automation Inc.** has received a \$3.5 million contract from a division of **General Motors** to build a 42-station automated assembly and test system for disc caliper brakes. The John Brown line is part of the GM 10 program to produce the new, large-body W-car that will be introduced in 1988.

► James I. Murphy, president of **Androbot, Inc.**, announced in a December 5 letter that **Michigan Robotics Corporation** had defaulted on its agreement to purchase certain Androbot assets. Androbot, according to the letter, has a cause of action against Michigan robotics, but "the assets of Michigan Robotics are believed to be limited," Murphy wrote. He continued that "the cause of action has doubtful value... and we are not hopeful." The

one additional inquiry Androbot received as to the possible purchase of its assets "turned out to be insubstantial." On December 3, the County of Santa Clara, California, seized the firm's assets. As a result of that action, Sysorex International, Inc. stated its intent to exercise its right as a first secured creditor of Androbot, took possession of Androbot's assets, and advised Androbot of its intention to convey the assets at a public sale. Androbot's total indebtedness to Sysorex was said by Murphy to be approximately \$1,186,750, plus interest that had accrued from various dates beginning in August, 1984.

► **Daimler-Benz** has placed a \$250,000 order for a machine vision system from **Perceptron, The Machine Vision Company**. According to Dwight Carlson, Perceptron's president and CEO, the order represents two firsts: the first major machine vision system to be installed in a European automotive plant, and the first order for the firm's recently launched European operations, headquartered in Munich, West Germany. The order is for an MV-300 multisensor system that will provide total quality control and process management. The system will perform 100 percent, on-line dimensional measurements on the "body-in-white" for the Mercedes-Benz 190 series.

► The **Delco Electronics** division of General Motors has committed approximately \$500,000 to a machine vision development project to be carried out at **Cognex Corporation**. The project's one-year goal is to build an engineering prototype

In The Robotics Age™

of a system that will inspect circuit boards containing small surface-mounted devices. Delco plans eventually to install such systems to inspect modules used in radios, engine controls, and other automotive electronic systems. According to Cognex's president, Dr. Robert J. Shillman, "Delco will not receive any exclusive equipment rights, royalties, or stock in Cognex," making the deal unlike GM's 1985 equity investments in five other machine vision firms. Based on the results of the Delco/Cognex feasibility study, Delco has committed additional funds to the further development of a complete solution to the SMD assembly inspection problem.

► **Unimation Incorporated** has established a 24-hour hotline for its industrial robots customers. According to the firm's Midwest regional manager, most customers perform maintenance and repair operations on second and third shifts. To access the Total Service Program, customers can call (313) 478-7780 collect and leave a message. The on-duty field engineer will return the call promptly, assist in problem solving, and make any arrangements required for next day emergency spare parts shipment. The service is available seven days a week.

► **Intel Corp.** and **Gold Hill Computers Inc.** have announced an agreement to jointly develop and market a concurrent version of Gold Hill's Common LISP programming language that will run on Intel's iPSC family of concurrent computers. The project is designed to produce a large-scale con-

current symbolic processing system and will expand the range of iPSC applications. Gold Hill's Golden Common LISP, a subset of Common LISP, is the most widely used language for developing artificial intelligence applications on the IBM PC, which is based on Intel's 8088 and 80286 microprocessors. According to a Gold Hill spokesman, concurrency is essential to large-scale symbolic processing for future applications such as robot navigation and battle management, which will require up to billions of computations per second, a considerably higher performance than can be achieved using sequential computers.

► **The Allen Group Inc.** has signed an agreement to license automated guided vehicles technology from **Meidensha Electric Mfg. Co., Ltd.** of Japan. According to an Allen Group spokesman, the agreement is part of an overall strategy intended to enable Allen to significantly expand its role in the field of factory automation. Meidensha is a leading supplier of sophisticated production equipment to the Japanese automotive industry.

► **Advanced Manufacturing Systems, Inc.** has announced that it will produce three flexible machine load/unload robotic systems for General Motors **Delco Products** operations. The systems will be used in the machining of clutch plate and cover plate castings on multiple spindle New Britain vertical lathes. Incorporated into each cell will be a GMF Model M-1A robot with special end-of-arm tooling capable of handling two

Circle 57

DIGITAL *Torgsyn*® REMOTE POSITIONER MODEL VTSND23-P2

**Microprocessor compatible,
self-contained
closed loop servo**

Features

- 8 and 16 bit input
- 10' accuracy
- Requires only ± 15 VDC power supply
- Continuous rotation, 400 rpm slew rate (max.)
- TTL or CMOS compatible
- Available in sizes 15, 23, 31 and 37, analog or digital mode
- Available torques from 2.5 to 100 oz.-in.

Applications

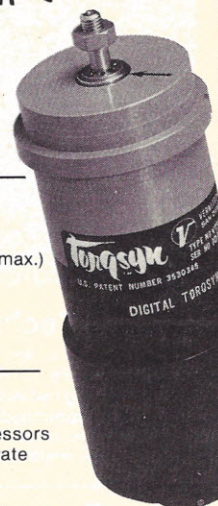
- Oil exploration
- Component testing
- Machine tools with on-board microprocessors
- Industrial processing to power and activate relays, switches, valves, etc.
- Robotics

Also available with 16 bit digital output and as analog units utilizing synchro or resolver input.

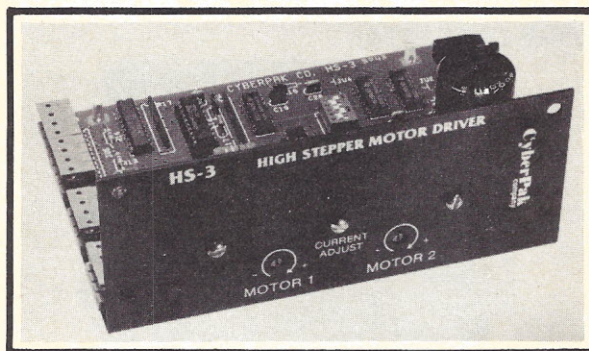
Call or write today for additional information or application assistance.



Vernitron San Diego
A Division of Vernitron Corporation
1601 Precision Park Lane
San Diego, CA 92073
Tel. 619-428-5581
TWX: 910-322-1862



16 Axis Step Motor Control Performance/Cost Break-Through



Cyberpak's BIPOLAR CHOPPER technology provides 2-5 times the performance of simple circuits. No external power resistors are required.

Complete 4 axis systems w/IBM-PC interface, including control system software (RBCS BASIC), at under \$1000. Driver modules start at \$89.50/axis.

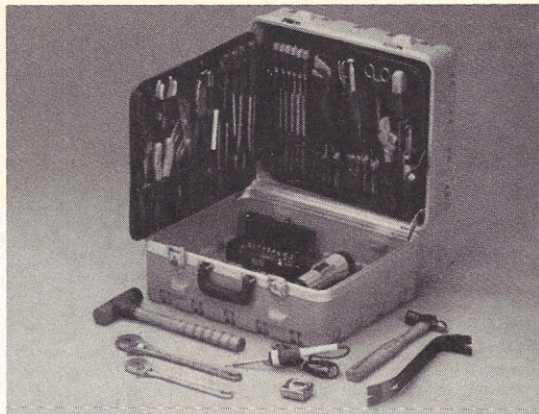
CyberPak
company

P.O. BOX 38 ■ BROOKFIELD, IL 60513 ■ 312/387-0802

MC/VISA

OEM and Distributor Pricing Available

Circle 43



Robotics Technician Maintenance Kit

New comprehensive tool kit for troubleshooting, service and repair of industrial robots. Contains tools for use with all types of drive systems including hydraulic, electric and pneumatic as well as servo and non-servo controlled equipment. Tools are adaptable to English or metric measurement and are contained in a super-tough polyethylene case with removable gate-swing pallets.

**Free
Catalog!**

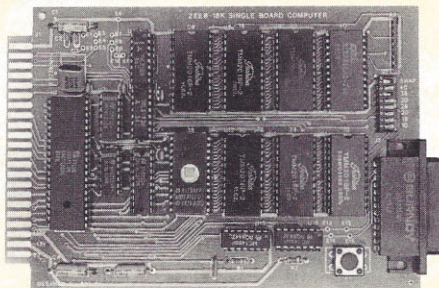
Features tool kits, tool cases and test equipment, plus a selection of hard-to-find precision tools.

JENSEN TOOLS INC.

7815 South 46th Street
Phoenix, AZ 85044 (602) 968-6241



**ZEE8-18K I/O CONTROL
COMPUTER COMBINES
PROGRAMMING EASE OF BASIC WITH
THE DISK-LIKE STORAGE OF AN EPROM
FOR ONLY \$239!**



The ZEE8-18K SBC combines the functions of computer + I/O board + EPROM writer + EPROM eraser—without the UV light and additional power supply needed for erasing and writing EPROM's. With an endurance of 10,000 write cycles per byte and the ability to erase/write **single bytes**, the EPROM can be used like a disk. Programs can be stored in tiny BASIC or Z8 hex code and will autostart after flipping an on-board DIP switch.

2K BASIC interpreter, 12K CMOS RAM, 2K monitor EPROM, 2K EPROM, 32 I/O lines, 2 counter/timers, RS-232C port.

MESANDD Microprocessor Engineering
1509 Francis Street, Albany, CA 94706
(415) 526-5155

In The Robotics Age™

green castings and two finished parts simultaneously. Delivery is scheduled for the early part of this year.

► **Adaptive Intelligence Corp.** and **Teledyne Ryan Electronics** have completed an agreement for delivery of a flexible printed circuit board assembly workcell based on Adaptive's core technology, the AARM. Teledyne Ryan manu-

factures small lot, short run PCBs specifically designed to meet military specifications and application needs. The workcell will handle multiple component geometries, as well as the automatic assembly of PCBs incorporating up to 160 different components. Strain gauges in the AARM's gripper will be incorporated as part of a multifunctional tool for board assembly.

INTERNATIONAL REHABILITATION WEEK

The first International Rehabilitation Week to be held in the U.S. will take place April 6-9 at the Jacob K. Javits Convention Center in New York City. The conference will feature seminars and workshops led by experts in medicine, science, research, engineering, manufacturing, education, government, and representatives of organizations for the disabled.

The convention will also include displays of electronic aids for the handicapped such as a "smart wheelchair" directed by head movements and also a voice controlled robot, under development by the Veterans Administration Rehabilitation & Research Development Service, that can perform domestic chores for the disabled.

CALL FOR PAPERS

The **IXth International Conference on Production Research** will be held August 17-20, 1987, in Cincinnati. Among the areas to be examined are robotics, CAD/CAM, and FMSs; application of systems methodologies; factory and office automation; and reliability and quality control in manufac-

turing. The deadline for submitting abstracts is December 1, 1986. Papers should be sent to Prof. Anil Mital, Conference Chairman, IXth Annual Conference on Production Research, Department of Mechanical and Industrial Engineering, University of Cincinnati, Cincinnati, OH 45221-0072.

In The Robotics Age™

PEOPLE

► The **Industrial Technology Institute** has named **Dr. Donald R. Falkenburg** vice president for research and development. He had been Director of the Institute's Flexible Machining Laboratory. ITI is the country's largest organization devoted exclusively to advanced automated manufacturing technologies.

► **William R. Tanner** has joined **Ingersoll Engineers Incorporated** as manager of special products. He has previously been associated with Object Recognition Systems, Inc., Tanner Associates, Ford Motor Company, and Chrysler Corporation.

► The board of directors of **Synthetic Vision Systems, Inc.** has appointed **Dixon T. Jarvis** president and chief CEO. Before joining SVS in 1983, Jarvis held executive positions with Burroughs, Control Data, Manufacturing Data Systems, and Multiple Access, Ltd.

► **Allen-Bradley**, a Rockwell International Company, has announced two appointments: **Michael Reitzel** to general manager of the firm's Automated Quality Equipment Division, and **Charles Clark** to general manager of A-B/Stromberg, a joint venture of Allen-Bradley and Kymmene-Stromberg Corporation of Helsinki, Finland.

► **ESAB** has promoted **Wade L. Chase** to MAC marketing specialist. MAC is the ESAB's Mechanized Arc Center, a new robotic welding hardware and

software system the company designed and is manufacturing at its Fort Collins headquarters and plant. ESAB has also named **Richard G. Fisher** Sales/Applications Engineer. Fisher has worked for S.J. Smith Welding Supplies.

► **John Dexheimer** has joined **American Technologies, Inc.** as director of controls technology for the firm's Automated Factory Systems Division. Dexheimer was formerly with the General Electric Company.

► **Prab Robots, Inc.** has appointed **John Espelage** to the new position of vice president and chief financial officer. Espelage has worked for Portec, Inc. and for Deloitte, Haskins & Sells.

► **AKR Robotics** has named **Peter H. Griffiths** director of sales and marketing. Griffiths was previously associated with Digital Equipment Corporation and Cincinnati Milacron.

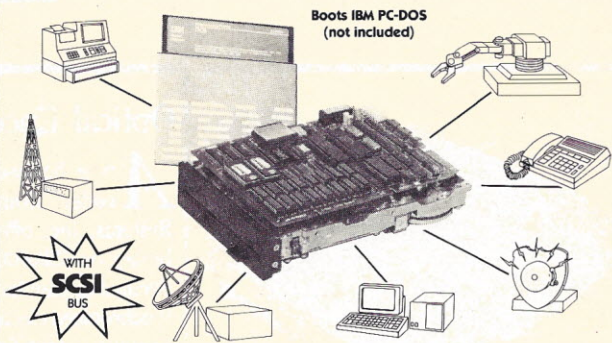
► **Akira Yamada** has been promoted to president of **Seiko Instruments U.S.A., Inc.** Yamada came to this country as general manager of Seiko Instruments and 10 years ago led the firm's entry into the robot business.

► **Byron C. Hedges** has joined the Automation Systems Division of **Wickes ADEC** as sales manager, Robotic Systems Integration. Hedges was previously with Kulicke & Soffa Industries, Sonobond Ultrasonics, and Struthers-Dunn, Inc.

Circle 39

Little Board™/186....\$495

High Performance, Low Cost PC-DOS Engine



- Three times the COMPUTING POWER of a PC
- Data and File Compatible with IBM PC, runs "MS-DOS generic" programs
- 8 MHz 80186 CPU, DMA, Counter/Timers, 128/512K RAM, zero wait states, 16-128K EPROM
- Mini/Micro Floppy Controller (1-4 Drives, Single/Double Density, 1-2 sided, 40/80 track)
- 2 RS232C Serial Ports (50-38, 400 baud), 1 Centronics Printer Port
- Only 5.75 x 7.75 inches, mounts directly to a 5-1/4" disk drive
- Power Requirement: +5VDC at 1.25A; +12VDC at .05A; On board -12V converter
- SCSI/PLUS™ multi-master I/O expansion bus
- Software Included:
 - PC-DOS compatible ROM-BIOS boots DOS 2.x and 3.x
 - Hard Disk support
- OPTIONS:
 - Expansion board with:
 - 128 or 512K additional RAM
 - 2 Sync/Async RS232C/422 serial ports
 - Battery backed Real Time Clock
 - 8087 Math Co-Processor
 - Buffered I/O Bus
 - STD Bus Adapter
 - Utilities source code
 - TurboDOS / Networking

AMPRO
COMPUTERS, INCORPORATED

IBM®, IBM Corp., 80186®, Intel, Corp., Turbo DOS®, Software 9000, Inc.

67 East Evelyn Ave. • Mountain View, CA 94041 • (415) 962-0230 • TELEX 4940302

FIBER OPTICS TO YOUR SPECIFICATION

...when "standards" won't do the job!

When "standard" fiber optic instrumentation can't meet a "special" remote viewing need — contact Reichert Fiber Optics.

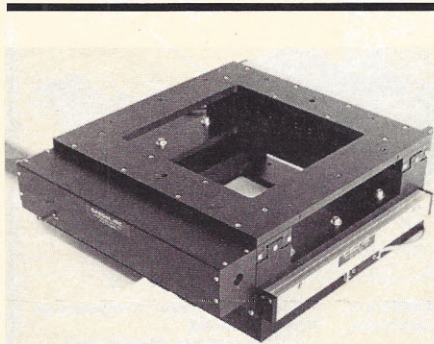
In order to answer the needs of "special" viewing situations, Reichert maintains a custom fiber optic instrumentation laboratory which will address unique viewing needs which "standard" instrumentation can't match. As an American manufacturer of fiber optic systems, Reichert has the capability to respond quickly to your "special" need. Call Reichert Fiber Optics at 1-800-343-6120 (In Mass. call 617-765-9744) to discuss your "special" viewing requirements.



Reichert Fiber Optics
Warner Lambert Technologies, Inc.
122 Charlton Street, Southbridge, MA 01550
1-800-343-6120
In Mass. call: 617-765-9744

Circle 59

New Products



Open Frame Tables Allow Either X or X-Y Axis Positioning

Daedal, Inc.'s open frame positioning tables are designed for applications that require a large center window through which light can pass or on which objects can be mounted. Either X or X-Y axis positioning can be achieved. The preloaded ball-bearing system permits precise straight-line movement accurate to 0.00025 in., the company says, and a precision ground lead screw provides accurate point-to-point positioning. Variables for table selection include desired travel, load capacity, lead screw pitch, and performance grade. Linear encoders, travel limit switches, and home switches are optional features.

For more information, contact: Robert Rebich, Jr., President, Daedal, Inc., PO Box G, Sandy Hill Rd., Harrison City, PA 15636, telephone (412) 744-4451. Circle 81

Digital Modular Encoder Uses Hybrid Technology

The Model 820A digital modular optical incremental encoder from Litton Encoder Division uses the recently developed hybrid chip with integrated sensors and amplifiers. The system is described as suitable for servosystems, motor speed controls, computer



Optical Encoder Provides Nonambiguous Output

A new heavy-duty, multiturn optical encoder from Sequential Information Systems, Inc. offers 2^{25} positions in natural binary or 720,000 positions in binary-coded decimal as standard. The geared encoders are synchronized electronically to provide a nonambiguous output free of gear train errors and backlash, the company says. Sealed against dirt, moisture, and oil, and incorporating a widely spaced shaft bearing assembly, the Model 40RMT is ruggedly built for use in hostile environments. The 40RMT contains handshaking electronics that permit interface to process computers or programmable controllers without requiring special interface logic.

For more information, contact: Murray Vinarub, Sequential Information Systems, Inc., 249 N. Saw Mill River Rd., Elmsford, NY 10523, telephone (914) 592-5930. Circle 83



Custom Shroud System Protects Robots

A SEA Robotics Inc. has developed a durable, fitted shroud for use on the company's IRB 60/2 robot in particularly severe environments. The coated nylon covering is available with varying amounts of attached aluminized heat shield. The shroud allows the robot to operate safely in very hot applications, such as near a gas-fired furnace operating at 2000°F.

The shroud comes with fittings for air lines to maintain a positive air pressure that prevents particles and dust from entering the robot. The shop air also helps cool the robot. Sheet metal mounting brackets hold the shroud on the robot arm. The shroud seats inside a metal hoop attached to the robot base; the hoop provides a seal against dirt, while allowing the robot unrestricted movement within its full working range.

For more information, contact: Thomas Bopp, Supervisor, Marketing Service, 16250 W. Glendale Dr., New Berlin, WI 53151, telephone (414) 785-3400. Circle 82

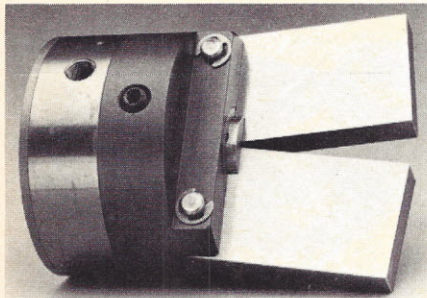


New Products

Lightscreen Has Space Barrier and Measurement Applications

The Model U LiteScreen from Xercon, Inc. is designed to cover an area 4 ft by 18 in. and will activate a built-in relay if any object 5/8 in. or larger enters the space between the Model U and the reflector unit 4 ft away. The lens pairs are 3/4 in. apart vertically; one emits a pulsed infrared beam, and the other receives the beam. Because of electronic sequencing, there is no interference between sets. The Model U can have a relay output to activate an alarm if personnel enter a robot's workspace, or an analog or digital output can be supplied so the size of an object entering the field can be measured to an accuracy of $\pm 1/2$ in.

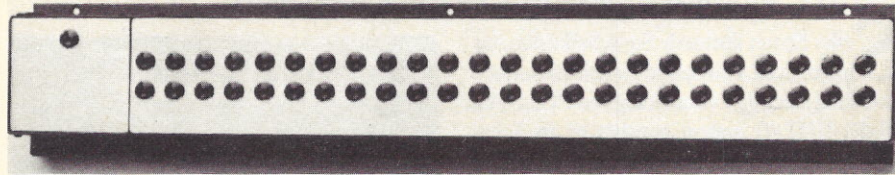
For more information, contact: George Osgood, Xercon, Inc., PO Box 554, Portland, OR 97207-0554, telephone (503) 292-8682. Circle 84



New Pneumatic Gripper Offers Finger Adjustability

A line of Pneu-Grip™ grippers from Fabco-Air, maker of the Pancake® cylinder, is designed for air operation up to 150 psi. Gripping can be internal or external, with forces from ounces to 750 lb. The finger adjustability feature allows both open and closed finger position to be adjusted, while mounted and with no disassembly. Other features include hardened finger clevises, bearing bronze clevis bearings, hard anodized housing, and hardened pivot pins.

For more information, contact: Robin Beckett, Director of Marketing, Fabco-Air Inc., 3716 NE 49th Rd., Gainesville, FL 32609, telephone (904) 373-3578. Circle 85



The Amazing A-BUS

Hobbyists, Engineers, Scientists, OEMs, and universities, the A-BUS is for you!

What is the A-BUS? The A-BUS is the best way to connect a variety of Input and Output cards (such as analog converters, relays, sensors, motor controllers, etc.) to your computer.

A typical A-BUS system consists of: • An Adapter Card and a Cable to convert your computer to the A-BUS standard • The A-BUS motherboard, with several slots in which you plug the different Input and Output cards • Your choice of cards listed below to fit your application. (Many more cards will be released soon.)

The "A" stands for Amazing, and here is why:

The A-BUS is designed to work with many different computers: IBM PC, XT, AT; Apple II's; and TRS-80 Models I, III, 4, 4P, 4D, 100, 1000. Should you ever move to another system, your investment is protected. Only the low cost adapter card has to be changed!

The system is expandable to meet current and future needs easily. Motherboards can be daisy chained for up to 20 cards.

Low cost and reliability will ensure your project success.

A-BUS Adapter for IBM's and compatibles. Uses one short slot
A-BUS Adapter for Model I Plugs into 40-pin I/O card edge (on KB or E/I)

AR-133...\$69

AR-131...\$39

A-BUS Adapter for Models 3, 4, 4P, 4D Plugs into 50-pin I/O bus.

AR-132...\$49

CABLE (3 ft.) to connect computer to A-BUS. One required for each system.

CA-163...\$29

A-BUS Motherboard, for up to 5 cards (not needed if using only one card) Includes sturdy anodized aluminum frame and card guides.

MB-120...\$95

MANUAL All the A-BUS products include a detailed user's manual.

A-BUS

Relay Card: RE-140...\$129

This industrial grade output card includes 8 relays. (Contact rated 3 Amp @ 125V) All the decoding necessary is included which means that you can connect up to 64 cards (which is 512 relays.) Easily controlled using "OUT" commands. For example OUT 1,0 turns all the relays off on card #1. Eight LED's show the states of the relays.

A-BUS

Isolated Digital Input Card: IN-141...\$49

This optically isolated input card makes it safe and easy to connect external devices (switches, thermostats, keypads) to your computer. Simple INP commands read the status (ON or OFF) of the eight inputs. Inputs can be Voltage (5-24V), Current (5-10mA), or switch closure. Full address decoding allows up to 64 input cards (that's 512 channels) per computer.

A-BUS

Analog Input Card: AD-142...\$119

8 channel 8 bit Analog to Digital converter. Your computer can read voltages, temperatures, pressures, light levels, etc. • Input range: 0 to 5.1 Volts. • Resolution: 20mV. • Conversion time: 120 microseconds. In BASIC, you can take up to 100 readings per second. • Port address: selectable. Up to 64 Analog-80's can be connected to your computer for a total of 512 channels!

An optional Amplifier board can be added to read millivolts: AM-169\$29

A-BUS

Dual Stepper Controller: ST-143...\$69

Don't be afraid of stepper motors anymore. The special package (below) includes everything you need to get familiar with steppers: • Controller card drives 2 steppers (12V bidirectional) ST-143...\$69 • Stepper: 48 steps per revolution, up to 300 steps/second, 1/4" shaft. MO-103...\$15 • Power supply PS-126...\$10

Special Package: Controller, two steppers and power supply: PA-181\$99

SPECIAL

Steppers: MO-103...4 for \$39

12V, unipolar, 7.5", 36 ohms, 1/4" shaft, 300 steps/second. Copal mfg model SP-57, same as Airpax K82701-P2. Regularly \$15 each.

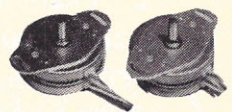
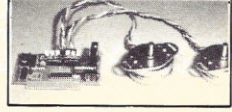
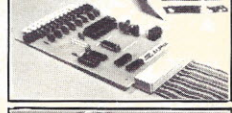
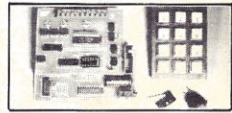
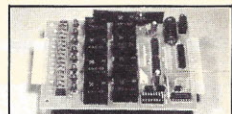
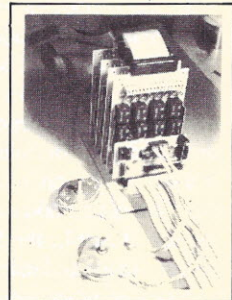
A-BUS

Prototyping card: PR-152...\$14

Protocard is 3 1/2 by 4 1/2 inches, and will accept up to 10 IC's

CABLES: Standard and Custom

Send for our standard cable flyer and our worksheet for custom cables.



**SPECIAL
4 for \$39**

ALPHA Products
79 04A Jamaica Ave., Woodhaven, NY 11421

800-221-0916
Orders Only, NY & info call
(718) 296-5916
Hours: 9-5 Eastern Time

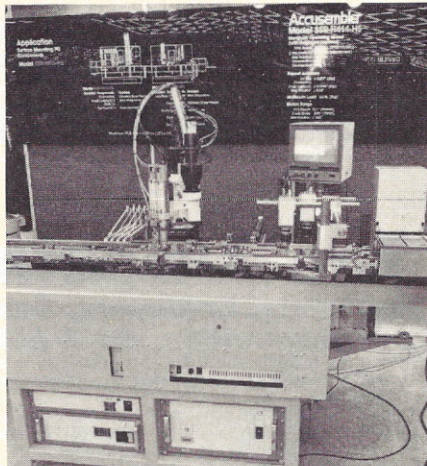
Add \$3.00 per order for shipping.
We accept Visa, MC, checks, M.O.
C.O.D. add \$3.00 extra.
N.Y. residents add sales tax.
Shipping to Canada is \$5.00
Overseas, PPO, APO add 10%

New Products

Surface Mounting System Can Be Customized

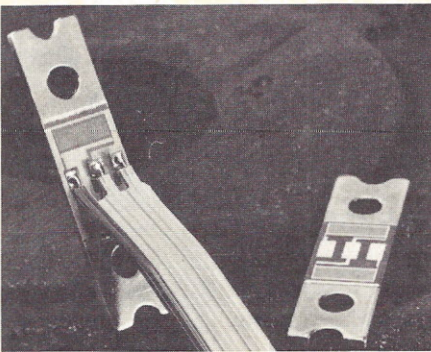
Seiko Epson (formerly Suwa Seikosha) has introduced a complete system for surface mounting electronic components on PCBs. The Model MMT-01 system consists of an Accu-assembler precision assembly robot and a modular family of feeders, end effectors, and transport devices that can be assembled to meet the user's specific needs. The SSR-414-HS SCARA robot can mount components on PCBs up to 13.2 by 10 in. in size; its flexibility permits varied line configurations. The system permits assembly cycle time of under 2.0 sec. and repeatability of better than 0.002 in.

Ancillary modules are end effectors; PCB cassette loader, unloader, and line conveyors; tape, stick, linear, and bowl component feeders; and linear and matrix pallets. Each unit is designed as an independent module with a dedicated unit controller and pneumatic control valves. The mounting order, position, and direction of part flow can be changed through the use of SPEL, the firm's robotic software system. An integral vision system can be added, and two or more mounting systems can be



linked for more complicated PCB assemblies, depending on line cycle time and number of parts to be mounted.

For more information, contact: Kanematsu-Gosho (USA), Inc., 400 Cottontail Lane, Somerset, NJ 08873, telephone (201) 271-7557/8/9. Circle 86



Force Sensor Has Integral Ribbon Cable

The FT30 Fast-Mount Force Translator®, new from Revere Corporation of America, comes with built-in ribbon cable to facilitate assembly into the final product. Models are available with sensing from 0-1 to 0-40 lb. The strain gauge-based transducer provides zero-offset stability over a wide temperature range. FT30 is 1.25 in. long by 0.312 in. wide and has half holes on the outer edges for rapid mounting in automated or manual assembly lines. The dual-guided cantilever beam design

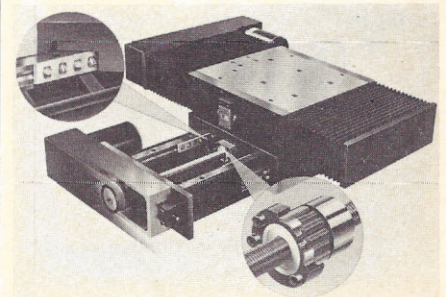
has low sensitivity to load position. Power is AC or DC, up to 10 V. Nonlinearity and hysteresis are ± 0.15 percent of full-scale output. Applications include medical instruments, computer input devices, and robotics.

For more information, contact: Revere Corporation of America, 845 N. Colony Rd., PO Box 56, Wallingford, CT 06492, telephone (203) 269-7701. Circle 87

MultiAx Positioning Tables Are Said to Provide Extreme Accuracy

The MultiAx positioning table, available from Tychoway Bearings Company, is offered in single or multiple axes and with or without motors. Designed for microchip wire bonding, the MultiAx has other applications, such as inspection, gauging, laser machining and welding, and assembly. The tables employ high-capacity linear guideway bearings for high reliability and performance. The recirculating design of the TychoTrax bearings eliminates the cantilevered overhang of standard crossed roller bearings. Available as components or as full turnkey systems with CNC, the positioning system offers many options and can be custom tailored to meet specific applications, including adhesive dispensing and computer chip inspection.

For more information, contact: Tychoway Bearings Company (a Cross and Trecker Company), 9432 Southern Pine Blvd., Charlotte, NC 28210, telephone (800) 438-5983; in NC, (704) 523-2088. Circle 88

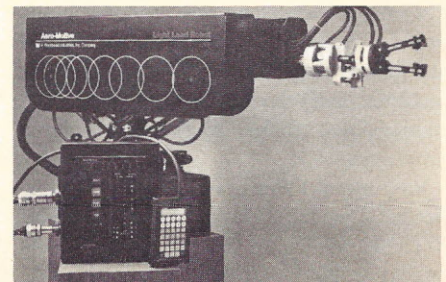


Pick-And-Place Robot Has Built-In "Noise Immunity"

The new LLR-10 is a pneumatic pick-and-place robot designed for light loads. Offered by Aero-Motive (a Woodhead Industries, Inc. company), the LLR-10 has a load capacity of at least 12 lb. and a 5-axis nonsequential movement. It weighs about 70 lb., can be fitted with a variety of end effectors, and can perform up to 600 complete cycles/hr. The built-in "noise immunity" prevents interruption by transient state electricity in plant wiring. The microprocessor-based controller requires 15 minutes to program and includes a self-diagnostic feature for troubleshooting.

For more information, contact: Richard J.

Hewitt, Aero-Motive/Woodhead Industries, Inc., PO Box 2678, Kalamazoo, MI 49003, telephone (616) 381-1242. Circle 102

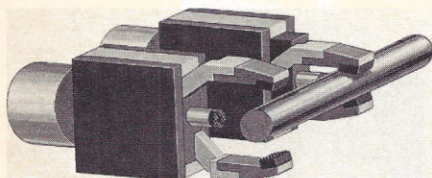


New Products

Gripper Uses Proximity Sensors

The True-Grip 3-point gripper from Arobotech Systems, Inc. has a true wedge, over-center design that allows its gripping points to move in a straight path to a common center line while maintaining constant pressure through its wide range. The robot can thus handle a large family of parts without reprogramming or retooling. The patented design includes as options retractable arms, i.d. and o.d. gripping, hydraulic and pneumatic actuators, and gripper positioning sensors. It is suitable for hostile environment applications. Custom design and engineering are available.

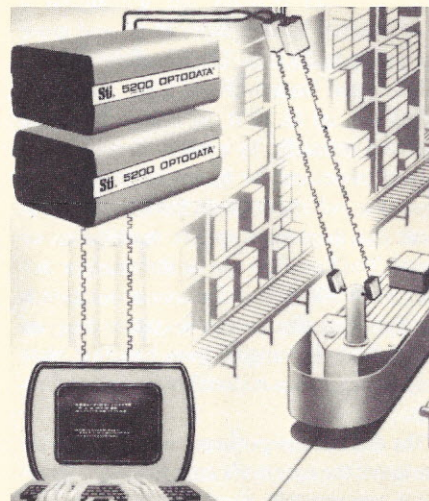
For more information, contact: Arobotech Systems, Inc., 2565 John B, Warren, MI 48091, telephone (313) 755-0007. Circle 100



Optical Data Transmission Device Eliminates Cables

The Model 5200 Series Optodata® offered by Scientific Technology Incorporated is a cableless line of sight optical data-transmission device that features pulses of infrared light that can carry asynchronous data up to speeds of 9600 baud. The system permits one- or two-way data transmission for serial or parallel devices, controls, and instruments. The 5200 Series can be used indoors and out and is available in several configurations, including the short-range, wide-angle model, which tolerates misalignment and can be used for transmission to moving vehicles, robots, and cranes. Transmission varies with the baud rate and will vary from 70 ft. for the short-range 5200 to over 400 ft. for the long-range 5200 in bright sunlight. Longer ranges are possible indoors.

The units are housed in rugged aluminum extrusion, sealed against moisture and dust. The system has a remote power supply that houses the data communication port. Input voltage is 117 VAC/230 VAC, 60/50 Hz, or 9-40 VDC. The long-range version transceiver is 7.5 by 20 by 2.90 in., and the short-range unit is 5.25 by 1.450 by 2.90 in. Applications



include automatic storage and retrieval systems and automated hoist handlers.

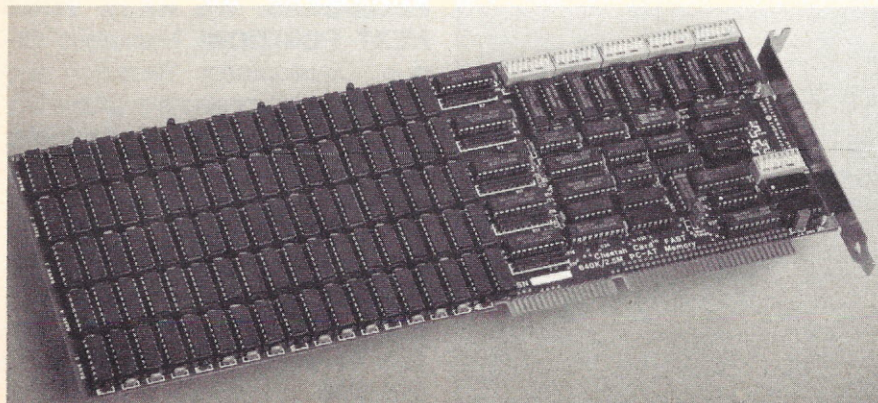
For more information, contact: Scientific Technology Incorporated, 1201 San Antonio Rd., Mountain View, CA 94043, telephone (800) 221-7060; in California, (415) 965-0910. Circle 101

New Board Adds Four Ports To An IBM PC-AT

The Cheetah TriComPlus™ allows the user to add three serial ports and one parallel port to an IBM PC-AT or compatible. The parallel port can be configured as either LPT1 or LPT2. The three serial ports can be configured as COM1, COM2, and, for special application software, the third can be assigned to either COM3 or COM4. If the PC-AT has a serial/parallel card, the three serial ports can be installed as COM2, COM3, and COM4 made

available for special application software. The parallel port can be assigned to either LPT1 or LPT2. If only one or two additional serial ports are needed, the TriComPlus can be installed in either an 8- or a 16-bit single slot, with the optional cable assembly removed.

For more information, contact: Cheetah International, Inc., 107 Community Blvd., Suite 5, Longview, TX 75606, telephone (800) 243-3824; in Texas, (214) 757-3001. Circle 90



Parts Removal Robot Is Designed For Limited Vertical Space

The Mold-Mate parts-removal robot has been introduced by Automated Assemblies. Designed for installations with low ceilings, the Mold-Mate enters the mold and removes the shot from the side of the molding machine. The straight horizontal motion allows the robot to remove shots that exceed the horizontal bar clearance and to accommodate molds with overhead obstacles such as unscrewing cylinders or vertical cores. No solder is required to retard the mold open or close stroke.

Other advantages are consistent molding cycles, reduced rejects, and mold protection. The robot can remove parts from 100-700 ton molding machines with a repeatability of ± 0.015 in. It can handle a 75 lb. payload with a minimum takeout time from the mold of 2 sec.

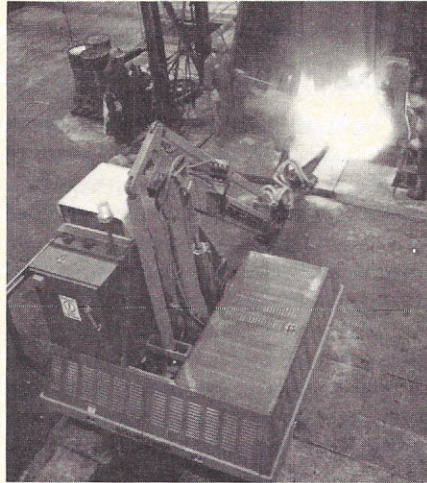
For more information, contact: Terri E. Ohryn, Marketing Coordinator, Automated Assemblies Corp., 25 School St., Clinton, MA 01510, telephone (617) 368-8914. Circle 103

New Products

Material Handling Robot Has 2000 Lb. Payload

Erie Press Systems has announced a material handler that can lift and move loads of up to 2000 lb. The Equalizer 200 can handle rated loads within a 25-ft horizontal radius and up to 14 ft in height. It can be operated manually, by a robot through seven axes of movement, or by any combination of manual or robotic controls through the teach mode that memorizes specific machine movements. The Equalizer can be stationary or mobile. A full 360-degree continuous rotation is standard. End effectors can be custom designed for applications ranging from handling plate glass to hazardous materials such as hot forgings.

The end effector performs virtually as an extension of the operator's arm; spatially proportional arm controls, along with operator feedback, simulate the movements of the operator's hand, meaning that the operator can feel what the machine is doing and respond appropriate-



ly. Since all machine functions are controlled with one hand, the other hand is free to operate other equipment via 24 interface circuits.

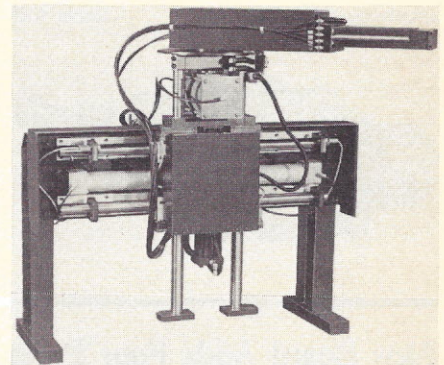
For more information, contact: Richard Kish, Erie Press Systems, 1253 West 12th St., Erie, PA 16512, telephone (814) 455-3941.

Circle 104

Pneumatic Robot Has Maximum Lift of 300 Lb.

A new line of large pneumatic robots offered by Robotech, Inc. includes the Model 400, a heavy-duty material handler with a payload of 100 lb. and a maximum lift capability of 300 lb. The standard specifications are four axes of movement: horizontal, 36 in., vertical, 12 in., arm rotation, 90 degrees, and arm extension, 12 in. Optional features are also available. Two-in. linear ball bearings provide vertical and horizontal motion. The cylinder and rod remain within the arm during arm extension. A mid-stroke stopping option is also available.

For more information, contact: Robotech, Inc., 250 Detroit Ave., Morton, IL 61550, telephone (309) 263-2602. Circle 105



Advertising

R.S. No.

Company

- 35 AEG Corporation, Cov. II
- 60 Adept Technology, Inc., Cov. IV
- 37 Alpha Products, p. 31
- 38 American Grinding & Machine Co., p. 2
- 39 Ampro Computers, Inc., p. 29
- 40 BEI Industrial Encoder Division, p. 3
- 41 Conco-Tellus, p. 13
- 42 Coret & Company, Ltd., p. 8
- 43 CyberPak Co., p. 27
- 44 Dorner Mfg. Co., p. 21
- 46 Heath Co., p. 35
- 47 Jensen Tools, Inc., p. 28
- 48 Laboratory Microsystems, Inc., p. 24
- 49 Mesandd Microprocessor Engineering, p. 28
- 50 Micromotion, p. 15
- 51 MillerEdge, p. 21
- 59 Reichert Fiber Optics, p. 29
- 52 Rhino Robots, p. 20
- 53 Robotic Accessories Division, p. 7
- 54 Robotic Industries Association, p. 9
- * 1986 Sensor & Transducer Directory, p. 17
- 61,62 Sensors Expo, Cov. III
- 55 Software Science, p. 26
- 56 Vernitech, p. 26
- 57 Vernitron Controls, p. 27
- 58 Wire Crafters, p. 23

* Correspond directly with company

Classified Advertising

ENGINEERS: WE HAVE YOUR NEXT POSITION! Numerous Design, Development, Research and Manufacturing positions available NATIONWIDE for degreed candidates with experience in any of the following areas: Robotics, Automated Systems, Control Systems, Artificial Intelligence, Hardware/Software. All Fees Company Paid. Contact: JAMES E. IANNONI & ASSOC., P.O. Box 128, Canterbury, CT 06331, (203) 546-9448.

the fourth law of robotics

A robot shall make learning fun for man and thereby improve the quality of life for mankind.

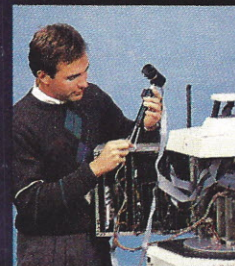


No other robot can match HERO 2000 for educational impact.

HERO 2000 is much more than a robot. It's a walking, talking 16-bit computer. With 64K ROM and 24K RAM expandable to more

than half a megabyte. And a fully articulated arm with five axes of motion. Centerpiece of a complete automation training system. With three comprehensive courses and experiments that cover all major automation concepts. An effective, affordable way to teach skills that

translate directly to the world of work. Backed by Heathkit/Zenith Educational Systems, world leader in technical training.



**FREE. Heathkit/
Zenith Educational Systems Catalog.**

Heathkit®
Heathkit/Zenith
Educational Systems

Heathkit/Zenith Educational Systems is a division of Heath Company, Benton Harbor, Michigan 49022

HERO[®] 2000

the
knowledge
builder



**Please send me more information about
the HERO 2000 Learning System.**

**Mail to: Heath Company
Dept. 529-398
Benton Harbor, Michigan 49022**

Name _____
Title _____
Organization _____
Address _____
City _____ State _____ Zip _____

RO-140

New Products

Pneumatic Positioners Offer Emergency Stop Capability

A new line of robotic positioning equipment from Fabspec™ is the GDX, with emergency stop capability not widely available on pneumatically driven positioners. The single-axis twin tables can handle loads of up to 2500 lb. on each end and operate efficiently, the company says, under any load within the operating parameters. Work surfaces are 30 in. on each end, with 60 in. center-to-center distance and repeatability of ± 0.002 in. at the table centers. Applications include robotic workcells in arc welding, adhesive, deburring, and assembly operations.

For more information, contact: Fabrication Specialties Company, Inc., 4160 Little York Rd., Dayton, OH 45414, telephone (513) 890-6700.



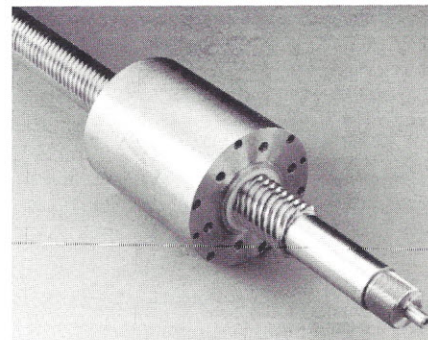
Auto-Step

Auto-Step, a compact L/R driver board with preset counter for four-phase stepping motors requiring up to 1.8 amp/phase is now available from Automation for Industry. The driver uses CMOS circuitry for low power supply sensitivity, high noise immunity, and an operating temperature range of -40°C to $+50^{\circ}\text{C}$. Power required for board and motor is a single $+15\text{V}$ to $+45\text{V}$ DC source with less than 10 percent ripple. Inputs are compatible with CMOS and TTL. Drive mode is full step (two phases on).

For more information, contact: Jack Wooster, Automation for Industry, Inc., 410 Great Rd., PO Box 518, Littleton, MA 01460, telephone (617) 486-9416. Circle 107

Roller Screws for Motion Conversion

Spiracon™ Planetary Roller Screws from ITW-Spiroid® are described as using simple design concepts to produce a superior performance in converting linear motion to rotary or rotary to linear. The devices are said to offer greater dynamic capacity and life/dependability, and state-of-the-art accuracy, even under the most arduous industrial conditions. Spiracon Screws can be custom-engineered for a variety of high-tech applications, including robotics, satellite antennas, machine tools, and medical equipment.



For more information, contact: ITW-Spiroid, 2601 N. Keeler Ave., Chicago, IL 60639, telephone (312) 227-2200. Circle 106

Literature

- **Factory Automation Publication Catalog.** Contact: The Manufacturing Technology Bookstore™, A Division of Tech Tran Corporation, 134 N. Washington St., Naperville, IL 60540, telephone (312) 369-9232.
- **Factory Automation Casebook.** Contact: Paul Gillespie, Walker-Davis Publications, Inc., 2500 Office Center, Willow Grove, PA 19090, telephone (215) 657-3203.
- **Just In Time: A Comparison of Japanese and American Manufacturing Techniques** (audio cassette tape program). Contact: Publication Sales, Institute of Industrial Engineers, 25 Technology Park/Atlanta, Norcross, GA 30092, telephone (404) 449-0460.
- **Manufacturing Simulation.** Contact: Technical Insights, Inc., PO Box 1304, Fort Lee, NJ 07024, telephone (201) 568-4744.
- **Strategic Issues in Automation Production: The Challenge of Robotics and Computer Integrated Manufacturing.** Contact: Manufacturing Technology Press, Inc., PO Box 206, Lake Geneva, WI 53147, telephone (414) 248-2200.
- **Robot Safety and Robotic Assembly.** Contact: IFS (Publications) Ltd., 35-39 High St., Kempston, Bedford MK42 7BT, England, telephone Bedford (0234) 853605.
- **The S. Klein Directory of Computer Graphics**
- **Suppliers.** Contact: Technology & Business Communications Inc., 730 Boston Post Rd., PO Box 915, Sudbury, MA 01776, telephone (617) 443-4671.
- **Solid Modeling Applications...The Real Payback.** Contact: CAM-I, 611 Ryan Plaza Dr., Suite 1107, Arlington, TX 76011, telephone (817) 860-1654.
- **Interfacing Techniques for STD BUS I/O Boards.** Contact: Bruce Alexander, Computer Dynamics, Inc., 105 S. Main St., Greer, SC 29651, telephone (803) 877-7471.
- **ICS Brochure on Real-Time Remote Data Monitoring and Control Instrumentation.** Contact: ICS Electronics Corporation, 2185 Old Oakland Rd., San Jose, CA 95131, telephone (408) 263-4844.
- **Model E3S Photoelectric Switch Catalog.** Contact: Omron Electronics Inc., 1 E. Commerce Dr., Schaumburg, IL 60195, telephone (312) 843-7900.
- **Laser Power Transmission in Optical Fibers and the Interaction with Robot Technology for Industrial Use.** Contact: National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22161, telephone (703) 487-4600.
- **Acopian 1986 Full-Line Power Supply Catalog.** Contact: Thomas E. Skopal, Advertising Manager, Acopian Corp., PO Box 638, Easton, PA 18042, telephone (215) 258-5441.

**ANNOUNCING THE FIRST NATIONAL
CONFERENCE AND EXPOSITION
DEDICATED EXCLUSIVELY TO
SENSOR AND TRANSDUCER TECHNOLOGY**

SENSORS EXPO

**O'HARE EXPOSITION CENTER, CHICAGO
SEPTEMBER 17 - 19, 1986**



**The sensor industry comes together in
September 1986 after years of being a
stepchild at other events.**

With major breakthroughs developing rapidly, the need for a focused, purposeful forum on the practical applications of sensor and transducer technology has become more acute.

This need will be answered at the first Sensors Conference and Exposition, sponsored by Sensors magazine and produced by Expocon Management Associates, Inc.

At SENSORS EXPO, design engineers, engineering and R&D managers, scientists, manufacturing and production executives, and corporate managers — all involved with the problems of measuring and controlling the physical world with computer systems — will be able to learn from industry experts and their colleagues.

And in the exhibit hall, they'll be able to examine a wide variety of products and components from the industry's most innovative suppliers.

If you'd like more information about attending, circle the appropriate Reader Service Inquiry number below. The complete program will be sent to you as soon as it's available.

Or, if you'd like the opportunity to exhibit, face-to-face, to thousands of engineering, manufacturing, and production specifiers, circling the second Reader Service Inquiry number will get you a complete Exhibitor Package.

For further information about SENSORS EXPO, contact Ginny Rae or Susan Reuter at Expocon Management Associates, Inc.
3695 Post Road
Southport, CT 06490
(203) 259-5734

For information about Attending, Circle 61
For information about Exhibiting, Circle 62

Why robot vision doesn't have to slow a robot down.

Most robot vision systems simply aren't good communicators. They load a robot down with more data than it can handle... and transmit that data over slow serial or I/O ports. So while they might "see" in real time, they can't make the robot react in real time.

AdeptVision™ can... and does.

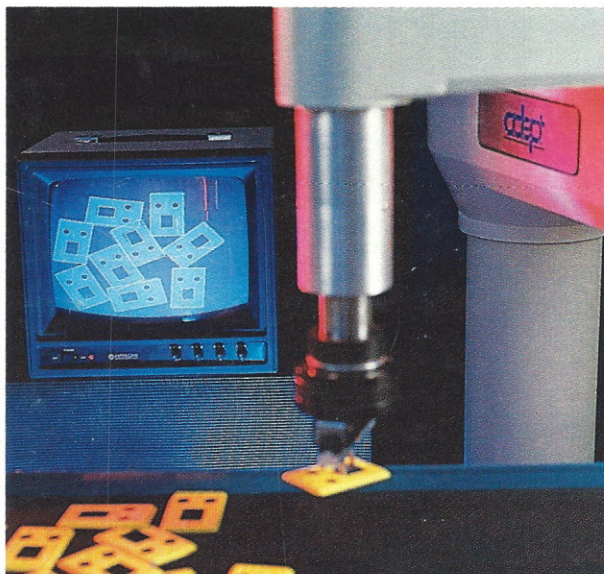
Real time vision, real time reaction.

AdeptVision communicates with the robot controller quickly because it communicates directly... in the same language... without any of the integrating hardware and software that slows other systems down and drives installation costs up.

In other words, AdeptVision comes fully integrated with the Adept robot system, and the result is sheer speed. In both its area and moving line versions, AdeptVision identifies and locates up to six parts per second—and communicates the information fast enough to guide the robot's path in real time.

Simplicity plus brainpower.

Most vision systems require special software for each part they handle. And most vision companies don't tell you



that. This can burn up several man-months of an expensive programmer's time and delay your start-up significantly.

AdeptVision requires no part-specific software. It's ready to go the day you install it and requires only about 15 minutes of training per part.

What's more, because AdeptVision identifies significant part features instead

of the entire part area, it accomplishes more with less raw data. And then turns it into real time robot guidance information with powerful 68000 processors.

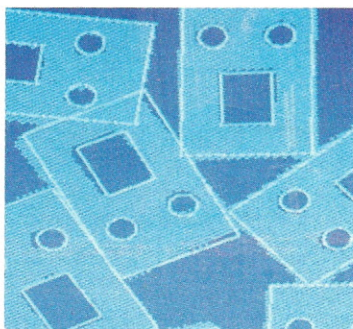
Touching and overlapping parts.

Most vision systems can't identify parts the way they're presented in real life: randomly oriented, touching, or even overlapping. AdeptVision can, because its unique algorithms work with part features instead of areas.

This flexible parts presentation ability can save you a fortune in hard tooling costs now... and later on when you change product mix or design.

Seeing is believing.

We'd like to show you AdeptVision in action... at an Adept-equipped systems integrator near you. Just give us a call, and we'll make the arrangements. In the meantime, we'll mail you all the details. Just contact Adept Technology, Inc., 1212 Bordeaux Drive, Sunnyvale, California 94089. Phone: (408) 747-0111. TELEX: 171942.



AdeptVision™ quickly identifies randomly oriented, touching, or overlapping parts.



adept[™]
adept
technology, inc.

Robots that work.